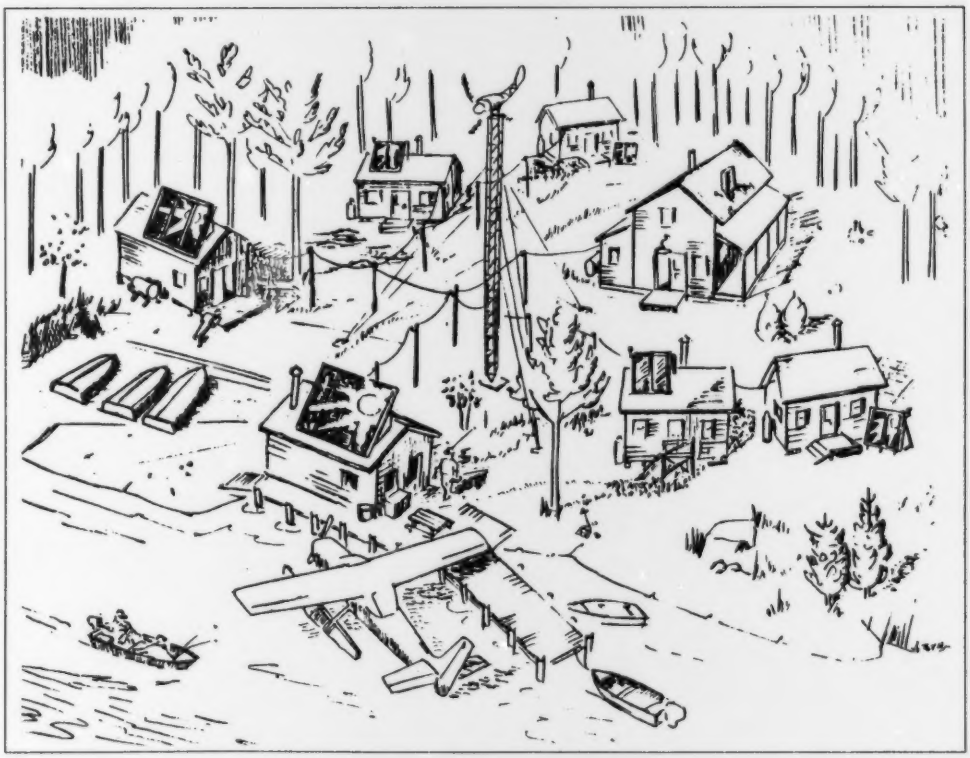
Energy Alternatives for Remote Lodges and Facilities



Ontario

Ministry of Energy

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Introduction

Operators of lodges and recreational facilities in remote (off-grid) locations face many economic and logistical obstacles to provide attractive, comfortable accommodations for Ontario's tourists. Space heating, hot water for personal hygene and laundry, electricity for lighting and other amenities are costly to provide in remote areas as most facilities now use gas or diesel powered generators with propane or kerosene heating to supplement wood fuel burning.

In this book, commercially available alternate energy systems and conservation opportunities suitable for Northern Ontario are described. Technical and economic information is included to help owners and operators identify and evaluate ways to effectively reduce their energy costs. This book is intended to provide sufficient information to enable an owner/operator to make a prelimianry assessment of the applicability of these alternate energy systems and energy conservation measures. Information about manufacturers and suppliers of products and services is included.

The Ontario Ministry of Energy recognizes that energy costs form a large part of the operating costs. This book is intended to help lodge operators reduce their energy costs and thereby contribute to making Ontario's lodge and recreational facilities more efficient and successful.

Energy Conservation

Most lodge operators are very conscientious about the amount of fuel their operation consumes each year. Many are considering conservation measures to further reduce their fuel costs without changing their existing power generators or heating equipment. This section on energy conservation will describe methods of energy conservation and present examples of how to determine whether a conservation measure is worth the time and expense to implement.

The examples provided are based on actual operations and are presented in a straight-forward, easy-to-follow manner. Costs for equipment and products are as current as possible, however owners/operators are advised to contact their local distributors for prices and delivery.

Conservation Measures

Several methods of conserving energy are available to the owner/operator. They include:

- Insulation
- Air Sealing
- Passive Solar Heat
- Heat Reclamation
- Lower Hot Water Temperature and Low-Flow Shower Heads
- Energy Management Systems
- Equipment Arrangement
- Selection of the Correct Size of Diesel Genera tor
- Cycle Charged Diesel Systems
- Ice Storage

Insulation conserves energy by limiting the flow of heat through walls, floors and ceilings. Heat is carried by air. Insulation works by limiting the flow of heat between cold regions and warm regions. Thicker insulation allows less cold to penetrate than thinner insulation and therefore works better. Several insulation materials are available including glass fibre, mineral wool, cellulose fibre and vermiculite. Do ***not use sawdust***. Although sawdust is a good insulator, it ignites easily and will spread a fire very quickly.

Air sealing conserves energy by limiting the flow of unwanted cold air, as opposed to ventilation which allows in wanted air. Proper air sealing requires a continuous vapour barrier, weather stripping, double or triple glazed windows, proper installation of doors and windows to prevent air leaks, and caulking of cracks, holes and building envelope penetrations for electrical or water service. While insulation and air sealing are advanageous, cabins with wood stoves must provide a source of air for the stove to support combustion. It is better to pipe this air to the stove rather than rely on air infiltration through the building envelope.

Passive solar heat means using the sun to the best advantage. When a new cabin is constructed, locate the cabin with a south orientation for maximum solar gain and with as many windows as possible facing the sun. This will provide a greenhouse effect. Windows should be equipped with drapes to prevent heat loss through the windows during no-sun periods.

Heat reclamation involves capturing and reusing heat that would have otherwise been wasted. Examples of this are:

- Use of waste heat from diesel/gas engine genera tor cooling jacket and exhaust to provide hot water for washing and laundry
- Use of cook stove waste heat for space heating
- Use of cook stove waste heat for hot water
- Use of a fireplace insert
- Use high efficiency wood stoves for space heating
- Use of fireplace heatilator
- Use of thermal storage devices
- Use of air-to-air heat exchangers
- Use of heavy curtains on windows to keep in heat
- Exhaust dampers on wood stoves to limit flow in windy days

Lowering the temperature setting on propane hot water heaters and using low flow showerheads can substantially reduce hot water heating costs.

Energy management means using energy only when necessary and combining activities to maximize energy use when it is used. Examples of energy management are:

- Operating laundry equipment during off-peak hours
- Using the correct size of diesel for lodge power
- Use of low wattage or fluourescent lighting

In addition, automatic electronic energy management devices are available. These can be programmed to limit peak loads by shedding non-priority loads when essential equipment is required, to run equipment in a specified sequence and to start and stop equipment at any time during a 24 hour cycle.

Equipment location can affect the amount of energy consumed by an appliance. For example, a refrigerator or freezer should not be located in the sun or near a heat source such as a stove. These appliances work best in cool shaded locations with plenty of ventilation. This will prevent the ingress of heat and improve their transfer of heat to the environment.

Selecting the correct size of diesel generator presents a difficult problem as daily loads vary considerably. Without a Cycle Charge or Energy Management System, diesel generators should be sized such that the generator is slightly oversized but the diesel is exactly sized for the peak load. Owners are encouraged to investigate the Cycle Charge or Energy Management Systems as these will save both equipment and fuel costs.

Ice storage of lake ice is a means of saving a convenience provided by nature and avoiding the cost of making or transporting ice for refreshments.

Insulation

Insulation will reduce cabin and lodge heating costs and increase guest comfort levels both in cold and hot weather. Several types of insulation are available in loose, batt or board form. Depending on the type of structure to be insulated, one form may be more easily applied than another. With all insulation it is important to install an interior continuous vapour barrier. Insulation must be ventilated to prevent a build up of moisture which will cause rot, mildew or deterioration.

The heat loss distribution for roof, floor and walls is shown in Figure 1. Shown also is the proper location of the vapour barrier.

Insulation should be applied to walls, ceilings and floors. The effectiveness of insulation is given by its R or RSI rating. The higher the R rating, the better the insulation.The heat loss distribution for foof, floor and walls is shown in Figure 1. Shown also in the proper location of the vapour barrier.

For example, glass fibre in batts has an R value of 3.2 per inch of thickness. Glass batt insulation with an R value of 12 is therefore 12/3.2 = 3.75" thick, the depth of 2x4 stud.

To calculate the heat loss through a surface:

$$\text{Heat loss per square meter (or square foot)} = \frac{\text{(Ti-To) Temperature difference}}{\text{RSI (or rating)}}$$

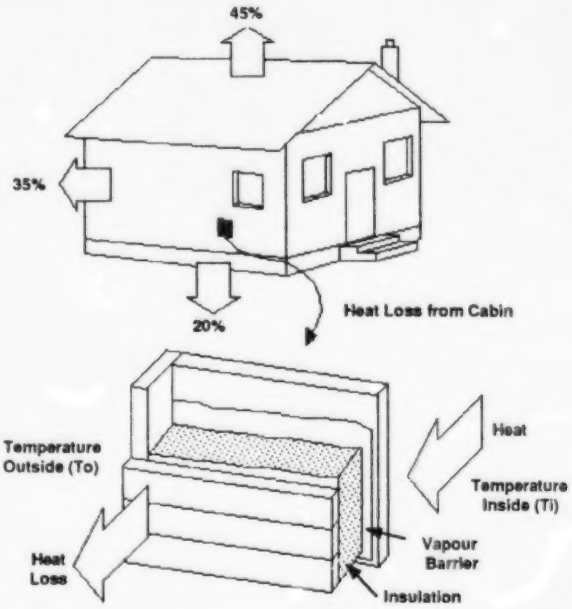
The R rating for an uninsulated wood frame construction cabin is about 2 to 3. The R rating for a log cabin wall 120 mm ($4^1/_2$") thick is about 5 to 8.

For a 25°F day with a 70°F inside temperature the heat loss for an uninsulated wall is:

$$\frac{\text{Temperature Difference}}{\text{Insulation Rating}} = \frac{(70-25)}{3} = 15 \text{ Btu / sq ft/hr}$$

With R12 the heat loss for the same wall would be:

$$\frac{45}{12+3} = 3 \text{ Btu / sq ft/hr or 80\% less}$$



Fligure 1
Heat Loss Diagram

Sample Calculation of Payback Period for Insulating

Cost of Insulating

Insulation	Floor	$A
	Walls	B
	Ceiling	C
	Installation	D
Total = A+B+C+D		= $T

Calculation of Savings per Year

Annual heating costs	$K
Annual air conditioning costs (if applicable)	R
Annual savings (assume 40%) =0.4 (K+R)	= $S

Calcutation of Payback Period

Payback period P = $\frac{I}{S}$

Calculation of Area to be Insulated (Figure 2)

Floor area = .875 WxL
Wall area = 1.75 H (L+W) less window and door area

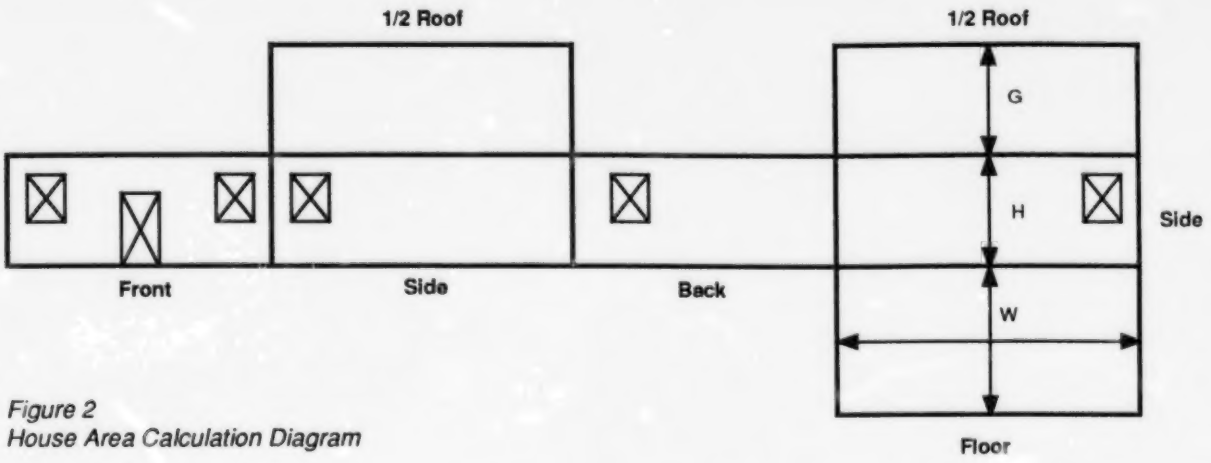


Figure 2
House Area Calculation Diagram

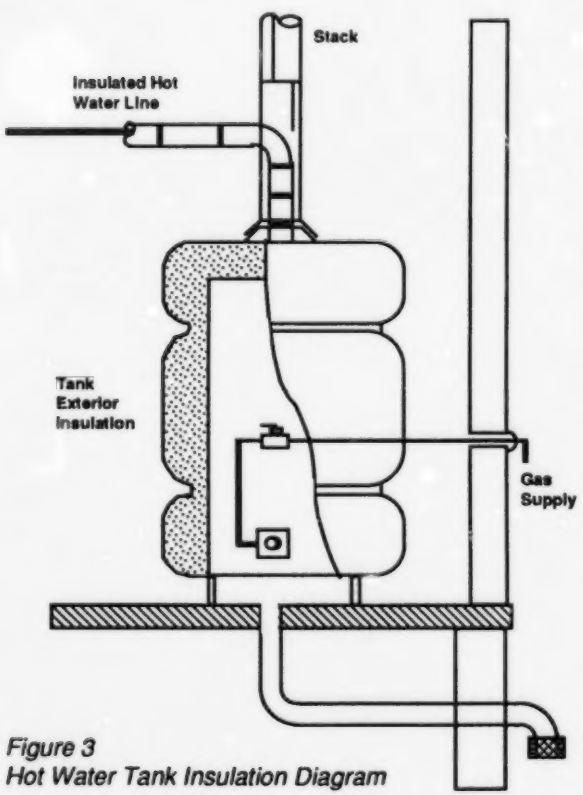


Figure 3
Hot Water Tank Insulation Diagram

Insulation of Hot Water Tanks

Propane and electric hot water tanks should be located inside the cabin or lodge. In addition to the insulation provided by the manufacturer, an external insulation wrap should be applied to the tank to limit heat loss to the environment. Combustion air should be piped to the hot water heater, complete with a pest screen on the intake as shown in Figure 3.

Hot and cold water lines from the tank should also be insulated for the first two metres. Uninsulated, this section of pipe will act as a heat exchanger to cool the tank.

Depending on the avialability of electric power, the owner may also consider using pilotless gas water heaters which employ an electric spark start. This will depend on whether a continuous pilot light costs more than the electricity to power the gas admission valve and the start electronics.

Very few remote lodges use electric hot water heaters as the propane units are less costly to operate.

Air Sealing

Up to 40% cabin heat loss is due to infiltration of cold air through holes and cracks in the building envelope and around doors and windows. Air leaks are caused by pressure differentials between the outside and inside of the building. Even on still days, the operation of a wood stove will draw air from inside which must be replaced. On windy days, the air pressure on the windward side forces air in and the suction on the leeward side pulls air out of the cabin (as well as increasing the air flow through a wood stove fireplace).

The prevention of infiltration of unwanted air requires a continuous air-vapour barrier, caulking of all fixed joints and penetrations and weather stripping of all moveable joints. Air sealing must always be done on the inside to prevent moisture entrapment. Exterior holes or cracks that will allow in snow or rain should be filled.

Air leaks can be detected using candle flame, cigarette smoke or a strip of tissue. An air leak will cause these to flutter.

Whether it pays to air seal can be quickly determined by comparing 40% of the annual cost of heating the structure with the cost to install air sealing.

Sealing Materials

Caulking is used to seal cracks or holes around window frames, door frames, electrical wire or pipe wall penetrations, baseboard joints wall and ceiling joints. Weatherstripping should be applied to moveable windows, doors, attic hatch and other moveable accesses. Fillers such as oakum, polyurethane foam or loose glass fibre are used for large openings and around the sill plate where the walls meet the floor.

Continuous air vapour barriers such as 0.15 mm (6 mill) polyethylene film should be installed between insulation and interior wall panelling. Sealant caulking is used to seal the edges of the vapour barrier. Using a caulking gun a continuous bead is placed on the building frame where the vapour barrier is to be stapled. The vapour barrier is pressed over the caulking and stapled in place.

Good quality caulking is required for sealing (20 to 25 year life expectancy) as this will remain pliable and maintain the integrity of the seal.

Air sealing is cheaper to install than insulation. However, if the owner intends to both insulate and air seal, the air sealing should be done on the interior walls with ventilation provided for the insulation.

Passive Solar Heat

Maximizing Solar Gain

When planning a new lodge, deciding on a location for a new cabin or clearing adjacent trees, take full advantage of the sun. Locating a cabin for maximum sun exposure will reduce heating costs. Plan to have the building facing south with the maximum amount of window glass facing the sun from mid-morning until dusk, as shown in Figure 4.

Windows should be equipped with insulating drapes to retain heat after sunset.

In addition a cabin or lodge, if it already faces the sun, can be further upgraded by the addition of a glassed-in sun porch. As shown in Figure 5, a continuous ventilation path should be incorporated with the building design to allow circulation of warm air to all areas of the building. To ensure the building does not become uncomfortably warm in hot weather, the building should have vents or windows that can be opened and closed near the roof to let excess hot air out. Opening floor level windows will let cooling air in. A centrally located stone chimney makes an excellent thermal storage device for both heat from the sun and heat from a hot fire.

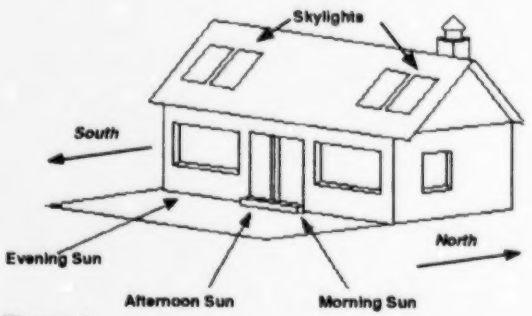


Figure 4
Preferred Building Orientation

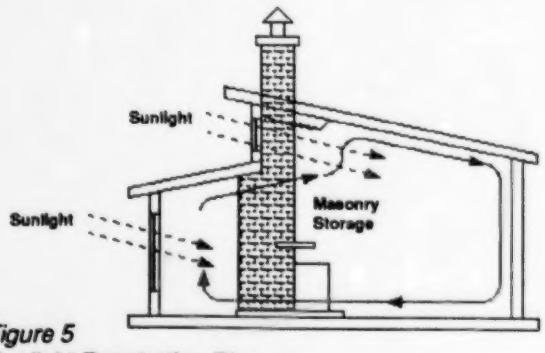


Figure 5
Sunlight Penetration Diagram

Heat Reclamation

Heat reclamation involves using as much heat from an energy source as possible before it is expelled to the environment. Methods of reclaiming heat are:

- Masonry Thermal Storage
- Cookstove Waste Heat for Space Heating
- Producing Hot Water Using Waste Heat from a Diesel Generator
- Air-to-Air Heat Exchanger

Masonry Thermal Storage

Part of the heat from a wood burning fireplace can be recaptured by locating the fireplace in the centre of the building and using a masonry chimney. The masonry will absorb the part of the heat from a hot wood fire that would have otherwise exited through the chimney. The masonry will then slowly release the stored heat and thereby provide more efficient space heating.

A stove or brick chimney, fireplace, or wood stove enclosure will also absorb heat from the sun. The masonry will release the heat when the sun is no longer available. The costs to install masonry storage are reflected in the cost of the building. Stone or brickwork is more costly than modern wood frame construction, and requires a qualified bricklayer or stone mason. Depending on the design used and the building arrangement with respect to the sun, masonry storage can save up to 20% of building heating costs.

Cookstove Waste Heat

Several lodge owners have found that by allowing air circulation between the kitchen and the rest of the lodge, the heat from the cookstove can be used for space heating.

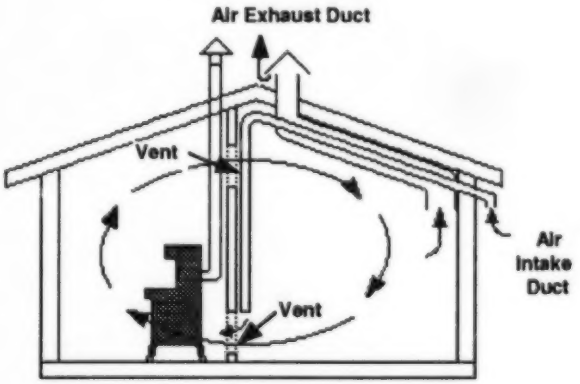


Figure 6
Air Circulation Diagram

The cost to use cook stove waste heat involves providing ventilation between the cooking area and the remainder of the lodge. Vents that can be opened and closed are preferred. To allow a continuous circulation path, floor level vents are required to return cold air and wall vents are required to transfer hot air to adjacent rooms, as shown in Figure 6.

Cook stove waste heat can also be used to heat water. This can be as simple as a pot placed on the stove or as elaborate as a pipe heat exchanger in the combustion chamber in conjunction with an elevated and insulated storage tank.

Air-to-Air Heat Exchanger

Air leaving a building contains heat, some of which can be recovered by using an aluminum drier vent pipe running through the centre of the exhaust air duct. Fresh air is brought into the building through the aluminum pipe. Heat is transferred from the exiting air through the aluminum to the incoming air. The fresh air intake should be located away from the exhaust duct exit to prevent recycling as shown in Figure 6.

Diesel Generator Heat Reclamation

Many lodges use diesels to produce electricity. While diesels are convenient and reliable, only 33% of the energy in the diesel fuel is converted to electricity. The remaining 67% is given off as waste heat. Part of this waste heat can be recovered by using both the diesel cooling system and by adding an exhaust heat exchanger to produce hot water.

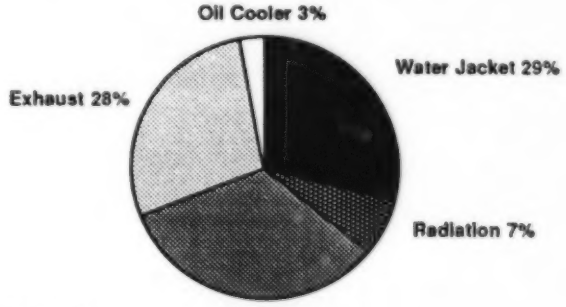


Figure 7
Diesel Generator Energy Breakdown

To use an example, a 15 kW diesel generatior at full load produces 15 kW of electricity and 22.5 kW of heat. About 70% of this energy can be reclaimed by recirculating water through the cooling jacket and exhaust heat exchanger. This is enough energy to heat (45 gallons) from (50° F) to (180° F) every hour.

Figure 7 shows where heat is lost from an operating diesel.

Depending on the age, type and condition of the diesel the owner can modify the cooling system as shown in Figure 8. New units can be purchased with a heat recovery option.

Before converting an existing diesel the following points must be considered:

- The cooling system must be cleaned thoroughly, flushed and pressure tested for leaks
- Infiltration of oil or exhaust gasses into the hot water are to be avoided as these will pollute the water
- The hot water storage tank must be sized to prevent overheating the diesel
- The engine must be protected from overheating as this will impair its performance and shorten its life
- An automatic cold water cooling supply, standby radiator, or overtemperature shut down control must be used

The engine distributor or manufacturer should be consulted before making any modifications.

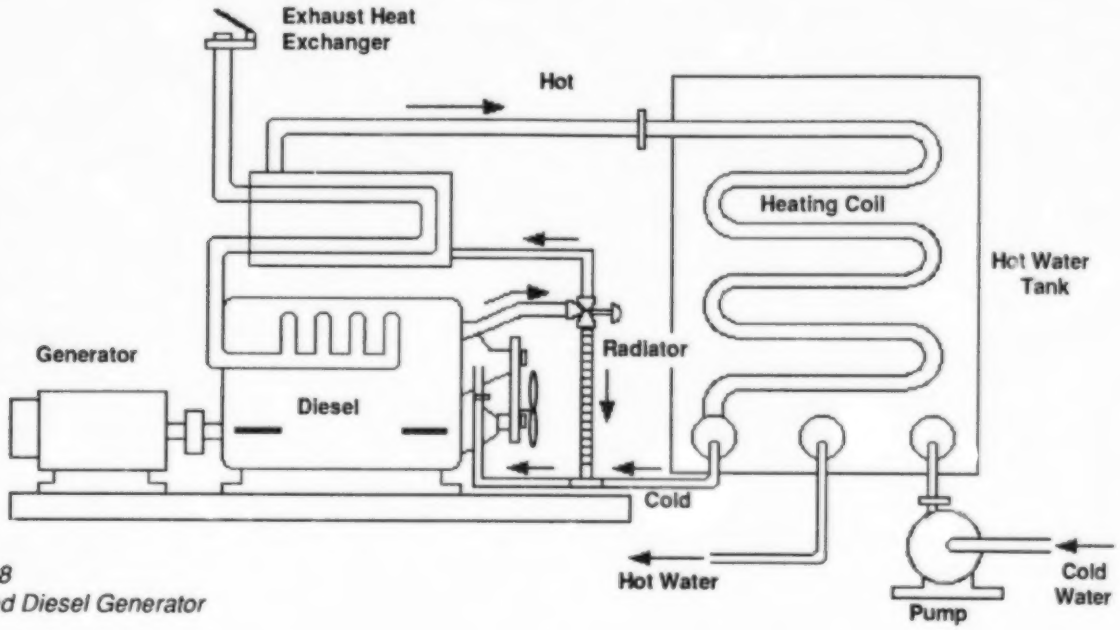


Figure 8
Modified Diesel Generator

Selecting the Correct Size of Diesel Generator

One problem faced by owners is how to choose the right size of diesel for their lodges. Should the owner buy two smaller units rather than one larger one?

The correct size can be calculated by adding up the number of power drawing devices and by understanding how these devices operate. Some electric loads are constant loads, electric lights for example. Motors, on the other hand, draw a large current to start and a smaller current when running. Electric refrigerators and freezers have a cyclic loading.

Electric loads are either constant or cyclic. Constant loads are steady like lighting, once turned on, the electrical draw does not vary. Cyclic loads are those which periodically come on and turn off, a good example being a refrigerator. Generally, cyclic loads require more starting power than while running.

Power requirements can be determined following these steps.

1. List all electrical loads

Constant loads	Amperes
Lights	
Radio	
Television	

Variable or cyclic loads	Starting Amperes	Running Amperes
Heaters		
Refrigerator		
Freezer		
Pumps		
Other		

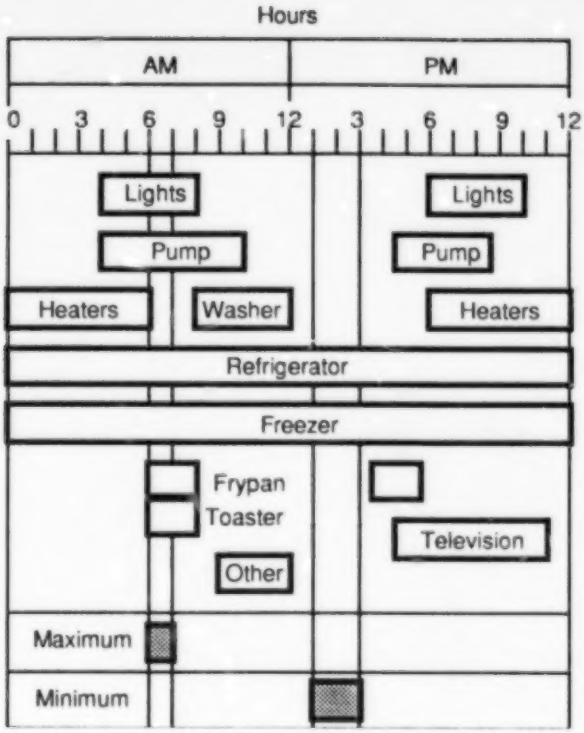


Figure 9
Maximum/Minimum Power Draw 24 Hour Diagram

2. Make a 24 hour chart similar to Figure 9 showing when each load comes on and goes off, with the minimum and maximum power draw shown for each electrical device.

3. For each hour of the day add up both the maximum and minimum loads.

4. Size the generator for 110% of the maximum draw. If two generators are used, size the smaller one for 125% of the continuous draw and the larger one for 105% of the remaining load.

Consideration should be given to a load management system which prevents the coincident starting of larger draw equipment such as the pump and freezer together. The freezer won't mind waiting a few minutes until the pump has established running current or has shut off.

With a load management system the generator size can be reduced to 110% of the running load and constant load plus the starting amperage of the largest motor.

While the generator should be slightly oversized, the diesel(s) should not be oversized as diesels work most efficiently at full load. Operating a diesel at partial load wastes fuel, causes carbon deposits in the diesel, reduces its operating life and increases maintenance costs.

Matching Generator Size With Lodge Load

Generators are rated in watts, kilowatts or kilovolt amperes at a given power factor. All very confusing.

1 Watt = 1 Volt x 1 Ampere x Power Factor

A 60 watt bulb on a 110 volt circuit has a :

$\frac{60 \text{ Watts}}{110 \text{ Volts}}$ = .545 amp load (power factor = 1.0)

There are two types of loads: resistance loads like light bulbs and baseboard heaters (pf = 1.0) and inductance electric motor loads which normally have power factor (pf) of 0.7 to 0.9.

Example

The lodge has a 5,000 watt generator rated at 6.25 kVA at a pf of 0.8 .

The lodge owner can estimate his load on the generator using Figure 10 on page 9. The Lodge has a 40 ampere resistance load and a 30 ampere inductance load. Can the generator accommodate this load? 40 amperes are measured on the resistance scale and 30 amperes are measured on the inductance scale. Using the Kilo Volt Ampere Scale, the power is measured from the 40 ampere resistance to the 30 ampere inductance giving an answer of approximately 9.5 kVA which means the load is too large for the generator.

How Much Energy Do Appliances Use?

Appliances are now required to display an equipment identification and rating plate. This states the manufacturer's name, the model number and the energy rating of the appliance. These plates are at times difficult to locate. A listing is provided on page 34 of this book as a guide to assist owners in determining the energy consumption of their lodges.

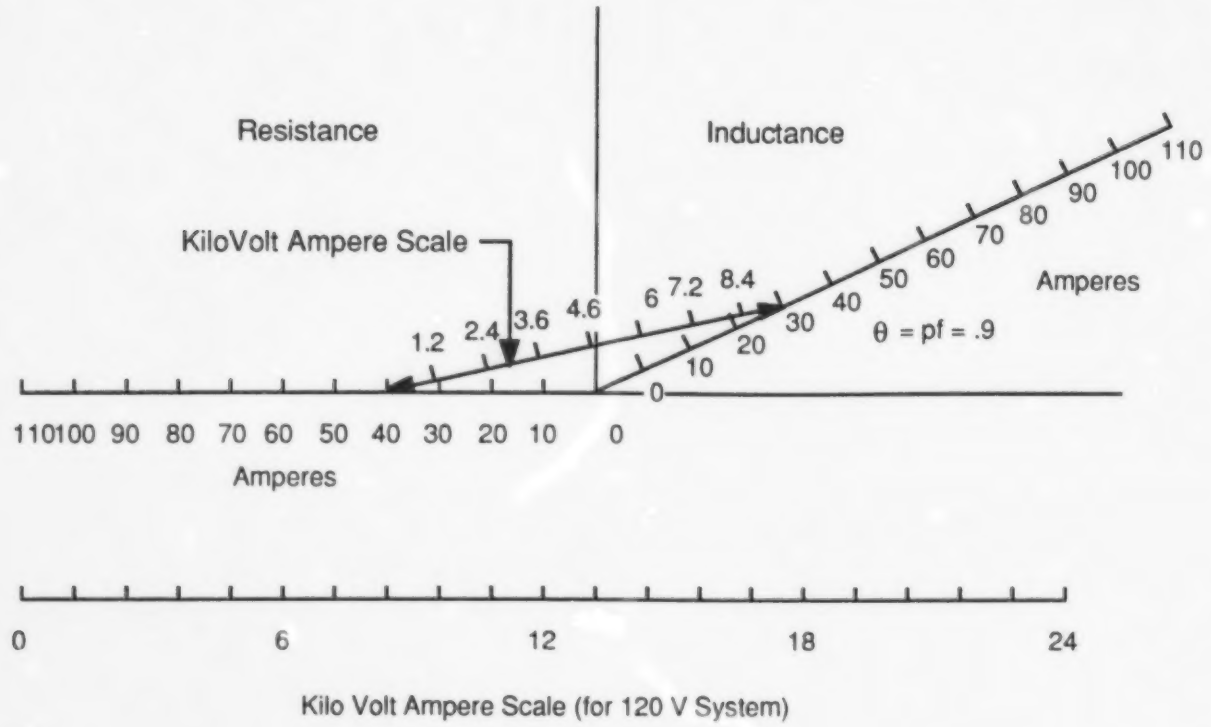


Figure 10
Diagram to Calculate the Load on a Generator (120 V System)

Cycle-Charged Diesel Battery Systems

The electric power demand for a lodge may vary considerably during a 24 hour period. Diesel generator systems are normally sized to meet peak loads and, as a result, run the majority of their life at part load. At part load diesel efficiency drops, the life of the diesel is reduced and maintenance costs are increased. Diesels are designed to run at full load continuously.

One method of coping with a varying load while using a constant load diesel is a cycle charge system. The Cycle Charge Diesel Battery System uses a diesel generator in conjunction with:

- A battery charger
- A battery bank
- A voltage regulator
  and, if 115 Volt AC power is required
- An inverter

The diesel is used to charge the battery bank through the battery charger and the voltage regulator. The voltage regualtor prevents overcharging the batteries. The lodge load is drawn from the batteries using either a 12V DC or 120V AC system. 115 Volt AC power can be produced from the 12 Volt or 24 Volt DC System using an inverter. With an additional transfer switch power can be drawn from both the batteries and the generator. Properly sized, the battery system will handle peak loads as well as normal loads. A low voltage switch will start the diesel to recharge the batteries. The benefit of this system is that a smaller diesel generator can be used thereby saving fuel and reducing initial cost.

Cycle-Charged Diesel Battery Example

A remote lodge has a normal load of 2,000 watts for 6 hours/day and a peak load of 5,000 watts for 1 hour/day.

A 5 kW diesel generator costs $8,000.00, the 2 kW $5,000.00.In terms of diesel fuel, each consumes 3.4 litres/hour and 1.8 litres/hour respectively. The large diesel uses 2.5 litres/hour at part load. Diesel fuel costs $.78/litre delivered.

The difference in fuel use for a 140 day season is:

Large diesel	
140 x ([1 x 3.4] + [7 x 2.5]) =	2,508.0 litres
Small diesel	
7 x 1.2 x 1.8 x 140 =	2,116.8 litres
391.2 litres	
391.2 litres x $.78/litre =	$305.14/season

Cost Comparison

Small diesel generator	$5,000.00
Battery bank, inverter, charger and regulator	$5,000.00
Total	$10,000.00
Large Diesel	$8,000.00
Difference	$2,000.00

The cycle charge system will cost $2,000.00 more installed however the system will pay back with fuel savings.

The Payback period is $2,000.00 (additional cost) / 305.14 (annual savings) = 6.56 years

Ice Storage

Many lodge operators store ice cut from the lake as a method of energy conservation.

Ice is cut into manageable-sized blocks and stacked on shore adjacent to the lodge. Sheet walls of any suitable material are constructed around the ice leaving a 0.30 m (one foot) space between the ice and the walls. A plastic sheet cover is then put over the ice. Insulation is then filled into the space and on top of the ice. Wood shavings or sawdust can be used since the risk of fire is low. A tarpaulin is then applied to the top of the structure for weather protection.

A 4m x 3m x 3m stack of ice will last most of the season if used reasonably and is properly maintained.

The entrance should be insulated and weather stripped. Ice should be drawn so that the stack remains a block as much as possible, thereby minimizing loss due to melting.

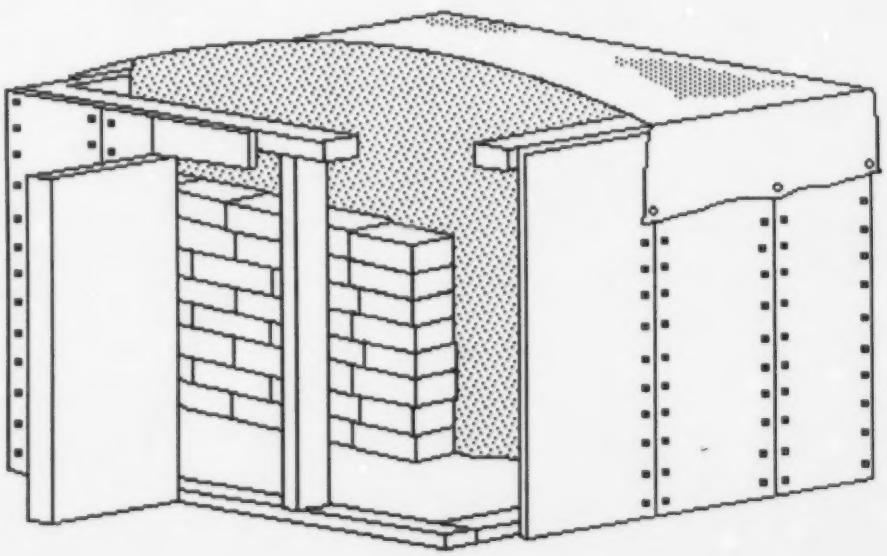


Figure 11
Ice Storage Building

Alternative Energy Sources

Many lodges now use propane for heating and diesel or gasoline powered generators to produce electricity.

While these are convenient, they are costly. Alternate sources of energy are available and may, depending on the location of the lodge, be more economically advantageous.

These include:

- Heating With Wood Fuel
- Small Hydro-Electric Power
- Wind Power
- Steam Engine Generator
- Solar Energy

Northern Ontario has an abundance of wood, sun and water. Use of these can reduce energy costs.

Heating With Wood

Northern Ontario has abundant wood supplies. Properly managed, wood can reduce heating costs substantially. The increase in oil prices during the 1970's prompted considerable research into the use of wood fuel. This has resulted in better designs of wood-fired boilers and space heaters which are now commercially available. The increased in use of wood has also led to better wood harvesting equipment and management techniques. Chain saws and portable hydraulic splitters are now widely used.

To derive the maximum benefit from wood fuel, it is necesssary to understand how wood is converted into energy.

Wood burns in four stages as temperature increases:

- Between room temperature and 100°C the wood is heated and dried.
- Between 300°C and 600°C combustable gases and liquids are driven out of the wood. These provide 1/3 to 2/3 the heating value of the wood. A slow cool fire will cause incomplete combustion of these gases and liquids. This wastes energy, causes air pollution, and causes creosote deposits in the chimney.
- At 600°C the gases and liquids are burned. This requires plenty of combustion air. For this reason a separate air supply duct to bring outside air directly to a wood stove or fireplace is recommended.
- At 800°C the remaining charcoal is burned providing the other 2/3 to 1/3 of the heating value.

Proper wood management requires that wood be cut to the desired length and split to a convenient size. This aids firing and drying. To properly dry wood, it must be stacked off the ground to allow proper ventilation. Normal drying takes about a year.

Fireplaces

Conventional fireplaces while attractive are only 10% efficient at best. If thermal storage and a combustion air duct are not provided, most of the heat goes up the chimney, along with a substantial amount of the cabin air. Air brought in to replace the lost air actually cools the cabin further.

Several methods can be used to improve the efficiency of a fireplace. The simplest of these is the installation of a tube grate or heatilator. This device pulls in cool cabin air at the bottom and pushes out hot air at the top. For more efficiency a fireplace insert can be installed. New fireplaces with heatliner/duct or heat storage systems can have efficiencies of 50% to 80%. A separate air supply duct from outside is recommended to provide combustion air.

Wood Stoves

There are two types of modern stoves: radiant and circulating. Both are equally efficient, however circulating stoves are safer as their exterior surface is not as hot.

When selecting a wood stove, there are two important considerations.

First — A short hot fire will result in more complete combustion of the wood. More thermal energy is extracted from the wood and subsequently less wood is used. For this reason a stove should not be oversized.

Second — Because the fire is short and hot a means of thermal storage should be provided. This will absorb the heat from the stove and then release it slowly. Brick or stone work adjacent to the stove provide a good means of thermal storage.

If a long slow fire is desired, stoves with secondary combustion chambers or catalytic combustors provide good heat transfer from a long slow fire yet burn combustible gases from the wood as well.

More efficient wood stoves and furnaces give complete combustion of the wood and use less wood as a result.

Small Hydro-Electric Energy

Some remote lodge owners have taken advantage of Ontario's abundant water resources to install small hydro-electric generators to provide the camp's power. Hydro power has the advantage of a free motive source and being non-polluting. Whether a lodge can use hydro power will depend largely on whether sufficient hydraulic head and water flow exist in close proximity to the lodge. Water flow should be measured when the river is at its lowest flow. As shown in Figure 12, this is done by selecting a uniform section of the river where the bottom is smooth and the river runs deep. Two parallel and level wire ropes are strung level across the river bed. The river depth is measured with a scale at convenient intervals (1/2 m). The Cross Sectional Area can be calculated by adding the interval areas across the river. Each interval area = 1/2 x 1/2 metre (width) x the measured depth at that interval. The water velocity (m/sec) is measured by tossing a small piece of wood into the middle of the river upstream of the first wire and measuring the time it takes for the wood to travel from the first wire to the second wire. The velocity will equal the distance between the wires divided by the time in seconds required for the wood chip to pass from the first wire to the second.

Stream Flow = Cross Sectional Area x Water Velocity

The hydraulic head (the difference in elevation between the water source and discharge) is measured using a level, a beam, a pole and a series of ground stakes. By measuring the difference in elevation between each stake, and by adding these differences together, the Total Hydraulic Head can be calculated as shown in Figure 13.

The power is estimated as follows:

Power = .114 x Stream Flow x Hydraulic Head x Turbine Efficiency

The amount of power that can be produced is dependent upon the flow and the head.

The power can be also calculated in horsepower as follows:

$$Power = \frac{Minimum\ Water\ Flow \times Head}{8.8}$$

or in metric horsepower as:

$$Power = \frac{Minimum\ Water\ Flow \times Head}{75/1\ 000}$$

To determine how much power would be available after losses, a rough estimate can be made by multiplying the power by 65%.

Example

A river from a lake has a summer flow of 20 cubic feet per second and a total head of 110 feet. For environmental reasons the lodge will only be allowed to use half the water.

$$\frac{10 \times 110}{8.8} = 125 \text{ hp or } 93.25 \text{ kW}$$

1 hp = .746 kW

After losses for the intake line and turbine efficiency, the net power would be 60 kW.

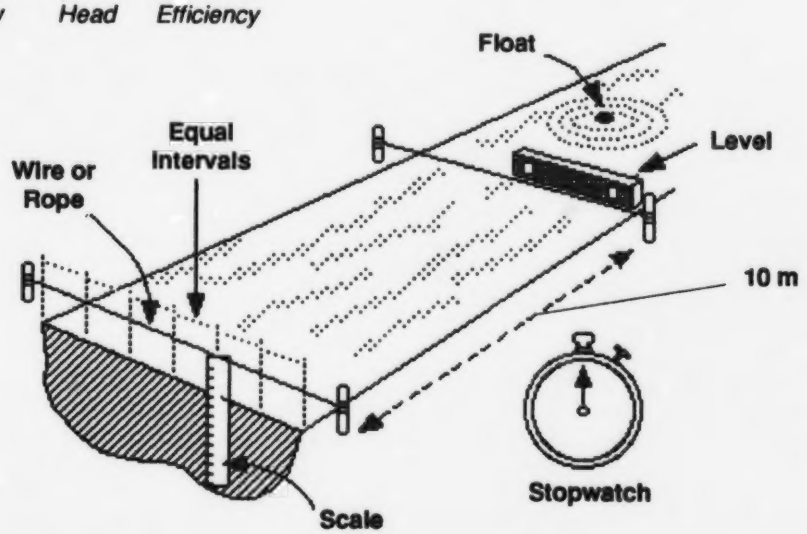


Figure 12
Water Flow Measurement

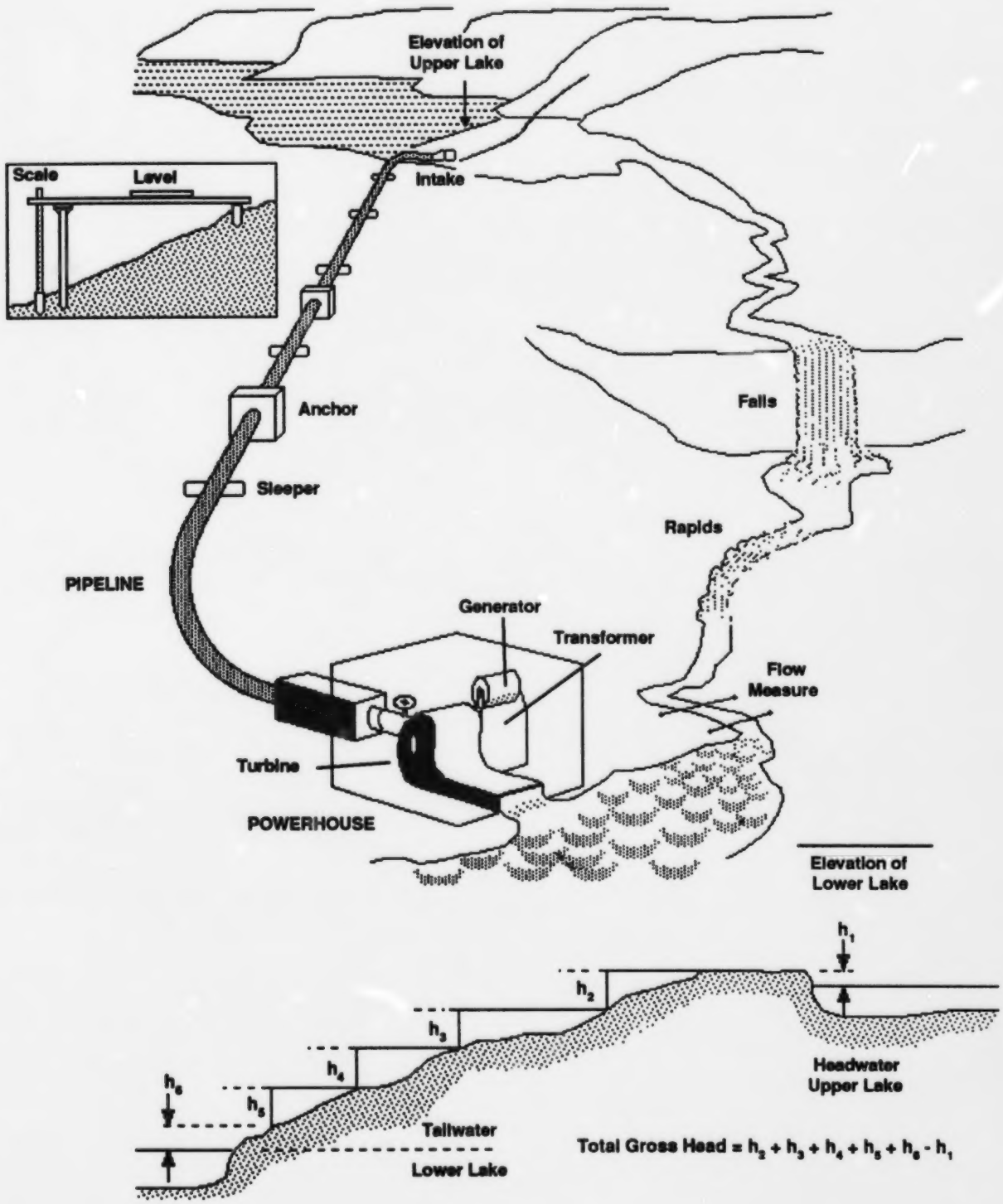


Figure 13
Measurement of Total Hydraulic Head

Wind Power

Wind power can be used for pumping water or producing electricity. This section concentrates on wind turbines used to produce electricity.

There are two types of wind turbines, the Stuart Mill (horizontal turbine) (Figure 14) and the Darrius Rotor (vertical turbine)(Figure 15). Wind turbines are available in sizes from 200 watts, to 500 kW. Four factors determine whether or not a wind turbine would be feasible for a lodge:

- Average wind speed
- Height of wind turbine
- Size of the wind turbine
- Cost

Wind velocities in Northern Ontario (50th parallel) average around 16 km/hr for regions from Kenora through Kirkland Lake. As shown in Figure 27 on page 37, areas where wind power has potential are on the exposed faces to winds from Lake Superior and above the treeline, places such as Bear Skin Lake and Big Trout Lake.

Propeller Diameter (In Feet)	Wind Speed (km/hr)			
	16	8	24	32
4	19	2	62	105
8	75	9	250	590
12	165	21	560	1,350
16	300	37	1,000	2,400
20	465	58	1,570	3,700
24	670	80	2,250	5,350
28	910	115	3,075	7,300
32	1,040	150	4,000	9,500

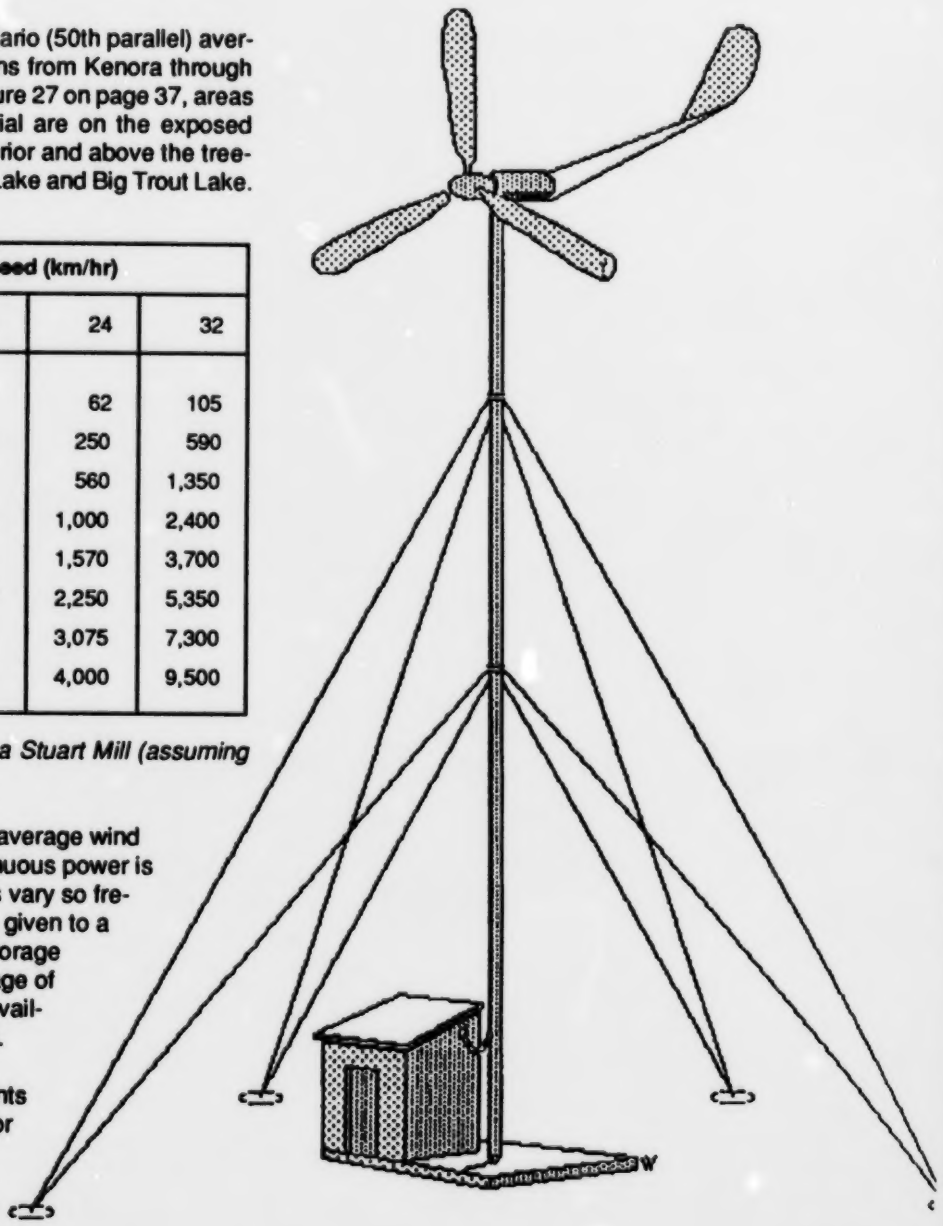
Theoretical output in watts for a Stuart Mill (assuming 49% efficiency).

In selecting a wind power unit, average wind speeds should be used if continuous power is required. Because wind speeds vary so frequently, consideration could be given to a wind power unit coupled with storage batteries. This will take advantage of higher winds and have power available during low wind conditions.

Depending on lodge requirements a small unit may be adequate for small loads such as communication equipment or site night lighting, when diesel operation is uneconomical due to low demand.

The first type of wind turbine is a Stuart Mill which is, effectively, a propeller coupled to a generator and mounted on a swivel. Since the wind velocity at ground level is reduced by trees and hills, the horizontal axis turbine requires a 10 to 30 metre support tower. The wind at this elevation has a higher velocity and tends to be more constant.

Figure 14
Stuart Mill Turbine



The second type of wind power unit is the Darrius Vertical Axis Turbine. This unit has the advantage of not requiring a tall supporting structure, however it is not self-starting. A diesel, or some other form of power is required to start it spinning. For this reason the Darrius turbine is normally installed with a diesel to both start it and produce power in low winds. In remote regions where fuel is expensive because it must be flown in, a wind turbine may well make sense.

When selecting a wind generator, it is important to remember that the power produced will vary with the wind speed. Wind generators are rated for specified wind speed. For example, a 200-watt unit produces full power in a 35 km/hr wind but when the wind speed drops to 16 km/hr the unit will only produce 120 watts. Allowances must also be made for light or no wind conditions as well as excessive wind conditions. To produce power a DC generator must be driven between a "cut in" speed and a "cut out" speed. In winds below the "cut in" speed, the generator is incapable of producing power. In very high winds, above the "cut out" speed, the wind turbine will apply an automatic breaking system to prevent structural damage. Depending on the wind conditions power will be produced only part of the time.

Exact cost and size should be determined through the manufacturer or a consultant. The following costs are provided only for estimating purposes.

200-Watt System

A 200-watt Stuart Mill Wind Turbine costs around $900.00. The support tower can cost from $500.00 to $1,000.00 depending on location and height. Guyed towers are cheaper and the tilt-down type are preferred as it is easier to do maintenance at ground level than at the top of the tower.

Foundations and anchor blocks may cost an additional $200.00.

Total cost:

Turbine	$900	200 Watts 12V DC max
Tower	750	(120 Watts 70% availability)
Foundations	200	
Batteries	300	
Regulator	150	
Total	$2,300	

Comparative Gas Generator

Gas generator - $640.00 (500 Watts 110v AC)
Fuel Consumption - 1/2 litre/hr
Fuel Cost - $.75 litre delivered
Expected Life - 5 years

Comparative Power Costs

In this example comparative power costs are calculated for a 140-day lodge operating season over 15 years. The gas generator operates 6 hr/day, the wind generator operates 24 hr/day, but due to wind conditions, produces power only 70% of the time. Since the life of a gas generator is 5 years, 3 units will be required over the 15 year period.

Gas Generator

Equipment Costs (3 units)	$1,920.00
Fuel (.75 x 140 x 6 x .5 x 15)	$4,695.00
Total	$6,615.00

Power generated $140 \times 6 \times \frac{(500)}{1,000} \times 15$ 6,300 kW hr

Cost per kWhr = 6,615 ÷ 6,300 = $1.05

Wind Turbine

Equipment Costs	$2,300.00
Fuel	0.00
Total	$2,300.00

Power generated $\frac{120}{1,000} \times 140 \times 24 \times 15 \times .7 = 4,234$ kWhr

Cost per kWhr = 2,300 ÷ 4,234 = $0.54

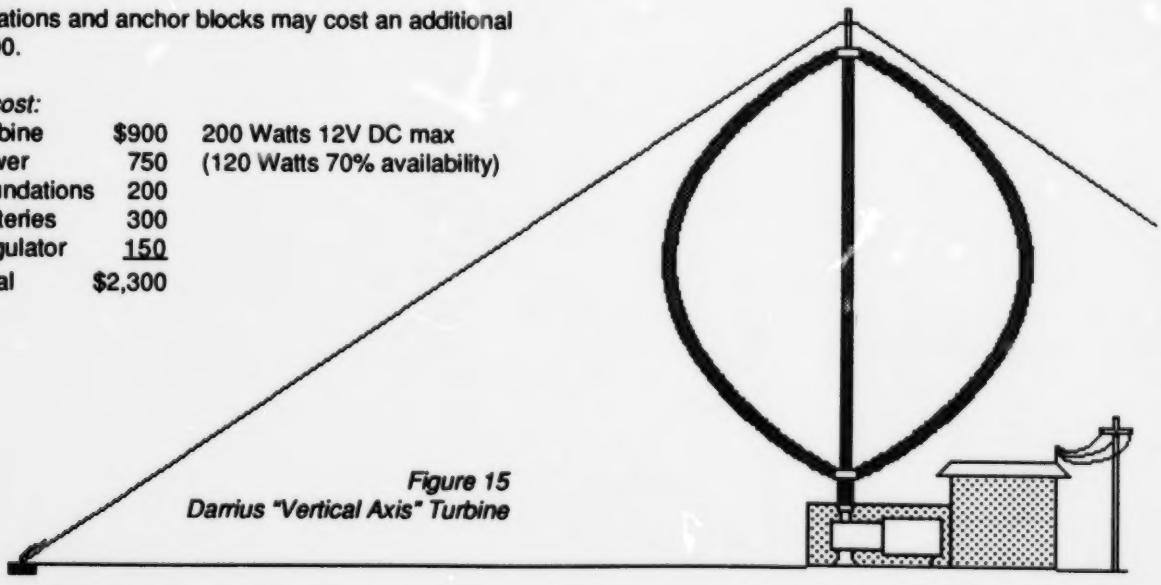


Figure 15
Darrius "Vertical Axis" Turbine

Boiler/Steam Engine

Very large lodges with the services of a registered Ontario Stationary Engineer can consider operating a wood fired high pressure boiler with a steam engine powered generator as shown in Figure 16. Power requirements of 50 to 100 kW would be applicable to available engine sizes.

Several factors must be considered:

Availability of Fuel - A 50-kW unit consumes between 60 and 90 pounds of wood an hour, depending on the heating value of the wood and its moisture content. For a 140 day season this would use 70 to 100 cords of wood.

Boiler Water Treatment - Raw water from the lake contains acids and dissolved or suspended solids which are harmful to boiler operation.

Regulatory Permits - Permission from the appropriate authorities are required to operate a boiler and steam equipment, to draw and discharge water, to discharge gases to atmosphere, to dispose of ash and to distribute electric power.

Annual Maintenance - The boiler and steam engine must be inspected and repaired periodically to prevent unwanted failures or personal injury.

Pollution and Fire Prevention - The unit will require a dust collector and spark arrestor.

Safety Systems - Safety devices are required to monitor engine speed vibration, steam temperature, boiler water level, bearing oil pressure and temperature. In addition an automatic shut-down system may be required depending on the type of unit employed.

Quantity of Wood Required

Wood varies in heating value depending on the species of wood and its moisture content. Typical heating values for dry wood (20% moisture) are given in the table below.

Typical Gross Heating Value for Dry Wood in Btu/lb

Pine	8930	to	9630	Btu/lb
Spruce	8980	to	8990	Btu/lb
Birch	8020	to	8650	Btu/lb
Poplar	8310	to	8920	Btu/lb

To appreciate this in cords, Birch weighs 3,680 lb/cord and Pine is 2,600 lb/cord.

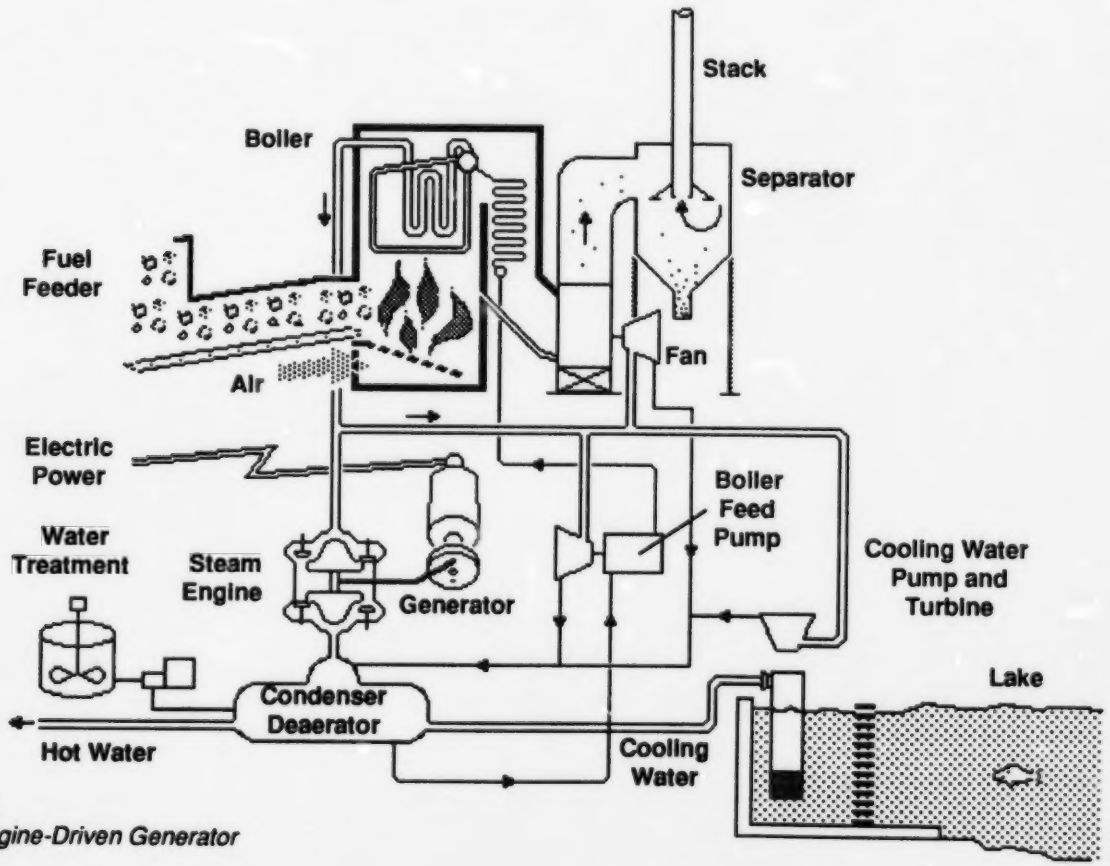


Figure 16
Steam Engine-Driven Generator

Theoretically 1 kW = 3,413 Btu, however calculations must account for moisture content, boiler efficiency, steam engine efficiency and generator efficiency. For example, wood with a dry heating value of 8,750 Btu/lb with a 40% moisture content will only give 4,400 Btu/lb. The remaining 4,350 Btu/lb will be lost to evaporate the moisture before the wood will burn. This lost energy can be minimized by drying the wood prior to firing. For calculating, wood dried outdoors for one year will give 60% of the dry value.

Representative efficiencies for equipment are listed as follows:

Boiler	75%
Steam Engine	80%
Generator	95%

To calculate the amount of wood required each hour:

$$\frac{50 \text{ kW} \times 3{,}413 \text{ Btu/1 kW}}{6{,}600 \text{ Btu/lb} \times .75 \times .8 \times .95}$$

= 45.46 lbs/hr, approximately 1/3 cord per 24 hour day

Like kindling, wood burns easier if the pieces are smaller. Lodges that have access to sawmill wastes can consider a screw type stoker or a pneumatic feeder where the fuel is blown from a silo into the boiler. Cord wood can be burned as cut from the bush but this method is not as efficient for combustion. A splitter can be employed to reduce the wood to more readily burnable pieces.

A schematic for a wood fueled power station is shown in Figure 16.

Representative costs for 50 kW unit are given in the adjacent table.

Cost analysis for a boiler steam engine alternative is given on page 24.

Cost to Install

50 kW Engine	$150,000.00
Boiler 2,000 pph @ 150 psig	$20,000.00
Generator	$16,000.00
Electrical Equipment	$6,000.00
Power Line	$2,000.00
Pumps and Controls	$5,000.00
Piping and Valves	$17,000.00
Foundations	$3,000.00
Structural	$5,000.00
Separator Stack	$5,000.00
Condenser	$20,000.00
Wood Fuel Feeder	$20,000.00
Engineering	$20,000.00
Construction	$40,000.00
Insurance	$6,000.00
Total Project	$335,000.00

These costs may appear unattractive at first until consideration is given to the use of the low pressure steam discharged from the engine. This steam can be used to heat the lodge and cabins, to heat water (rather than using propane) to power a refrigerator freezer and to operate an ice maker.

Boiler/Steam Turbine

Very similar to the steam engine, a steam turbine as shown in Figure 17 can be used for power requirements from 15 kW to several megawatts. Because the use of steam is so widespread in industry, several sizes and types of turbines are available. As with any high pressure steam equipment, a Registered Ontario Stationary Engineer is required for the operation of the unit.

The capital costs for a boiler/steam turbine system are considerably greater than most facilities can afford. However, developers of very large recreational complexes are encouraged to explore this alternative using the services of a consulting engineer.

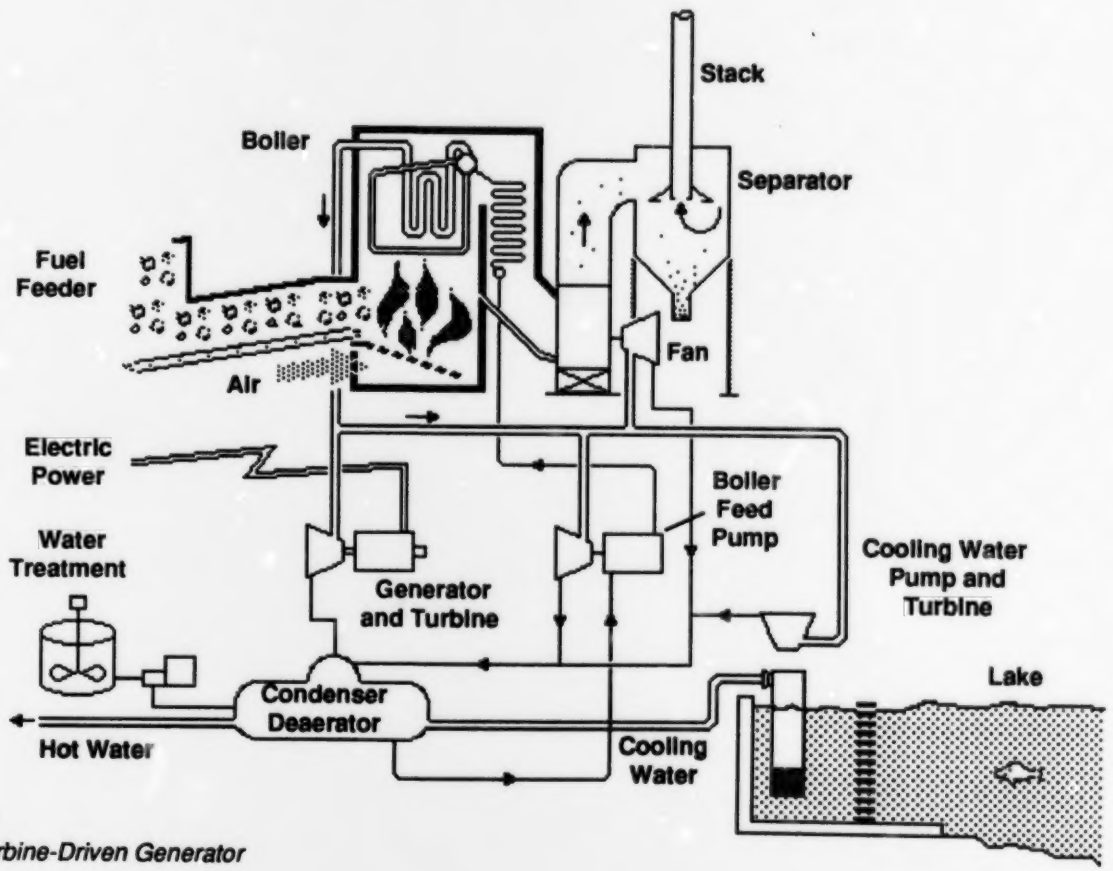


Figure 17
Steam Turbine-Driven Generator

Solar Energy

Northern Ontario receives more sun than many other parts of Canada, making the use of solar power attractive. While sunlight is provided free, harnessing its power requires a long term investment. There are basically two ways to capture the sun, **photovoltaics** and **solar collector systems**.

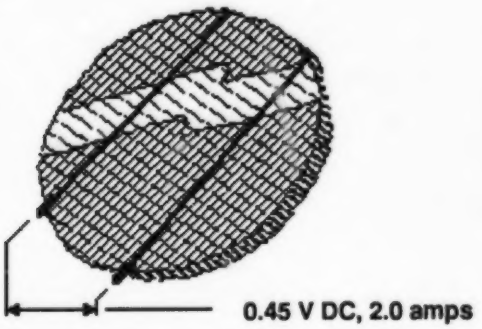


Figure 18
A Single Solar Cell

Photovoltaic cells like the on in Figure 18 are made of silicon and transform sunlight into electricity. Each cell produces 0.45 Volts at 2.0 amperes or 0.9 watts.These cells are normally sold as prefabricated modules containing thirty to forty 10 cm discs. These individual solar cells are about the thickness of cardboard. They are easily broken by bending or impact and accordingly they have to be supported and protected. The cells may be connected in series or parallel to suit the owner's preference. For example twenty-eight cells wired in series will deliver (28 x .45) 12.6 volts at 2 amperes output. The same twenty-eight cells wired in parallel will deliver (28 x 2) 56 amperes at 0.45 volts output.

Solar cells are usually employed in conjunction with storage batteries. An arrangement similar to Figure 19 provides power during overcast and dark periods. Three 36 cell panels will charge one 12V battery in one day. A voltage regulator is required to prevent overcharging. The battery area must be well ventillated to prevent a collection of hydrogen gas produced during charging. Hydrogen gas will explode in the presence of a spark or flame. The batteries must be emptied each winter and replenished with a fresh acid solution each spring otherwise the batteries will deteriorate over the winter.

Batteries used for this application are the industrial "deep draw" type. These have a life of about 15 years.

Battery charging requires a voltage in excess of 14.1 volts for a 12 volt battery and a rate of about 6 amperes for a 60 ampere hour battery.

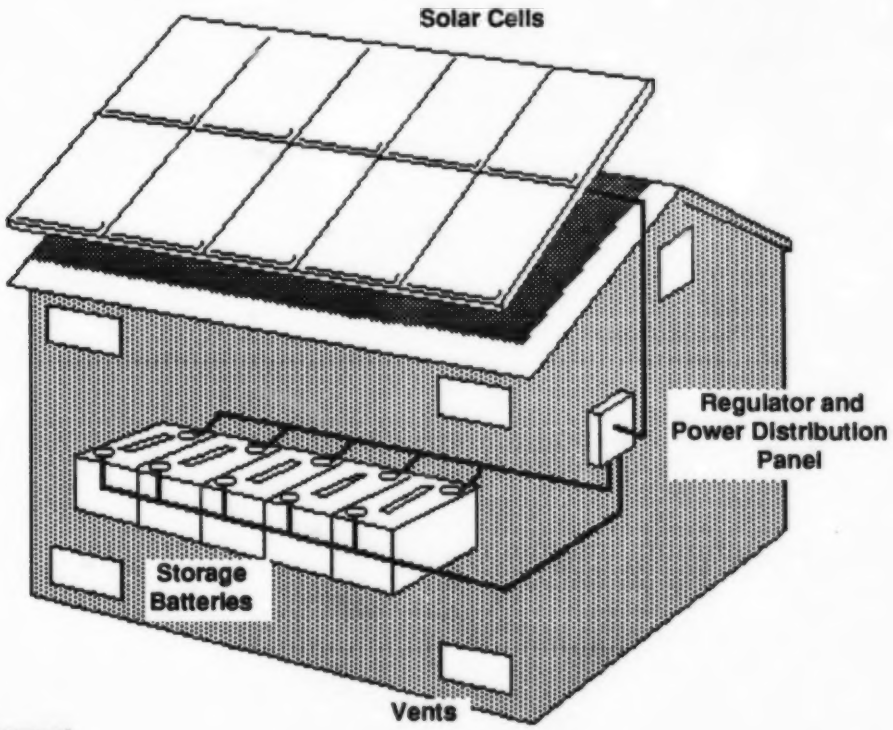


Figure 19
Photovoltaic Cell
and Battery Arrangement

A solar cell/battery arranagement can be used for camp lighting, communication equipment, radios and 12 volt appliances, the type used in recreational vehicles.

(A 12 V refrigerator draws 3 to 5 amperes, a television 2 to 3 amperes and a standard car radio 0.1 amperes per hour. A car headlamp draws about 10 amperes while the tail light or courtesy bulbs draw 1 to 2 amperes.)

Alternatively, an inverter can be used in conjunction with photovoltaic system to produce 115 V power.

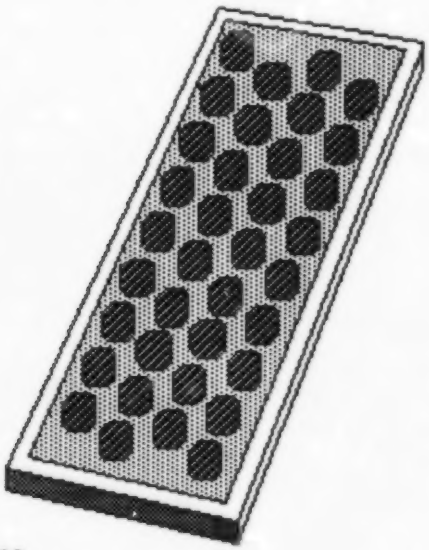


Figure 20
A 36-Cell Array Module

A typical 36 cell solar panel shown in Figure 20 costs about $600.00* and will produce 16.2 volts at 2.19 amperes. The life of these modules is about 30 years. The cost per watt varies from $16.00* to $50.00* depending on the unit and quantity purchased.

Alternatively the lodge owner may want to use industrial nickel cadmium batteries rather than lead acid batteries. While these are more costly they do not require annual maintenance.

Solar Collector Systems

Solar heat can be used to produce hot water for washing, showers and other uses. The collection of solar heat requires a solar collector, a water storage tank and in some cases, a pump. Solar collectors are available as commercially prepackaged units or can be fabricated from commercially available materials.

*1988 prices

Two types of solar collectors are available, the plate type Figure 22 and serpentine type Figure 23. The plate type solar collector is made of a frame, a back plate, insulation a glass cover and a solar collector plate. The collector plate is normally made of copper or steel and has water passages connecting the bottom supply line to the top discharge line. The glass gives a greenhouse effect while protecting the collector from rain, snow and dirt. The insulation and back plate prevent heat loss to the environment. The frame facilitates mounting the collector.

A second type is the serpentine collector which uses a continuous black plastic tube arranged in bundles through which water is pumped.

Solar collectors can be operated without a continuous running pump by using the thermo syphon effect as shown in Figure 21. Water always contains dissolved air. Heating water causes this air to expand in effect making the water lighter. The hot water will rise and the cold water will fall to replace the hot water.

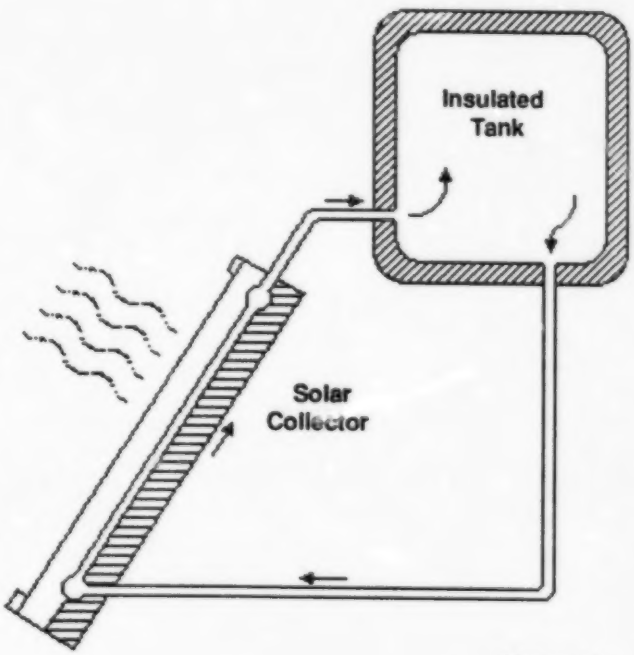


Figure 21
Thermosyphon

A solar collector can be made from an eavestrough, corrugated roofing and plastic pipe. As shown in Figure 24, water is pumped from the storage tank to the top distribution pipes. The full length top pipe has small holes drilled along its full length. This allows small streams of water to trickle down the face of a matte black surface (corrugated roofing) and be subsequently collected by

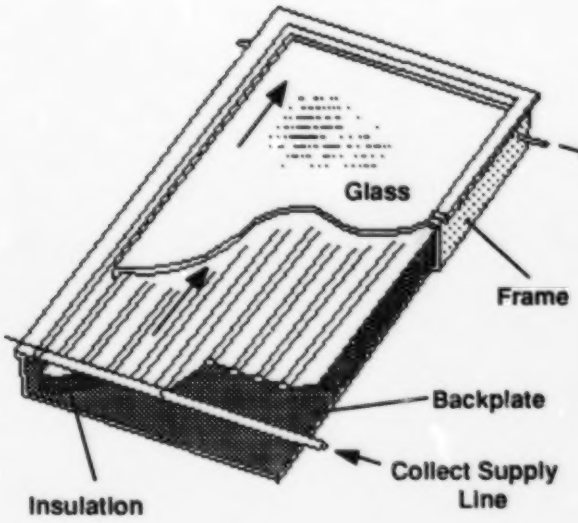


Figure 22A
Typical Solar Collector

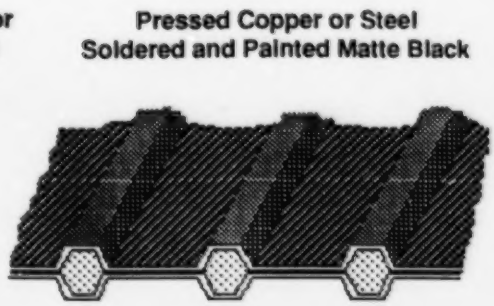


Figure 22B
Collector Plate Construction

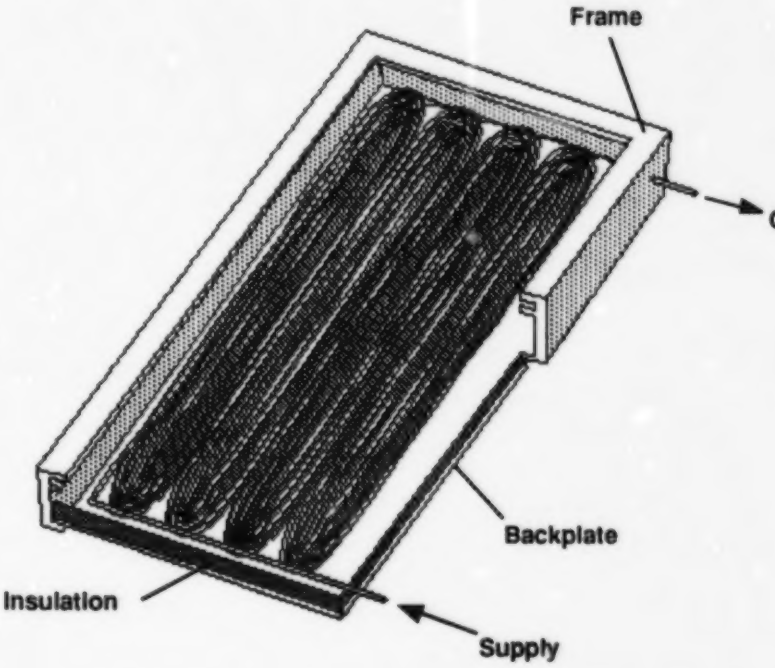


Figure 23A
Serpentine Solar Collector

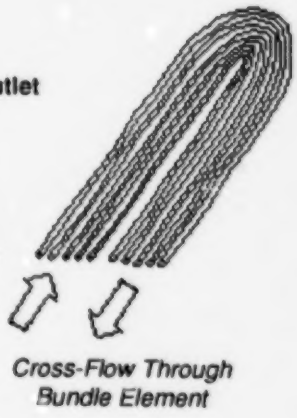


Figure 23B
Tube Bundle Arrangement

an eavestrough. Sunlight on the matte black surface allows the release of heat. The heat is transferred to the water as it passes over the surface. While less expensive than manufactured systems, this system does lose some water to evaporation. It can also be used as a rainwater collector. Removal of airborne dirt and leaves may require a small amount of maintenance.

Solar system kits are available commercially and are made up of two panels, tubing, a pump, controls and a tank (Figure 25). These have a rating of 250 Btu/sq ft (1Btu will heat 1 lb of water 1°F). Separate panels can be purchased for $450.00 to $600.00 each depending on construction.

The size of the solar collection system is determined by the amount of available sunlight in the lodge area and the hot water requirements. A rough estimate of hot water requirements can be made by allowing 10 gallons per person per day.

Solar collectors can be mounted in various locations, however they must face south such that their exposure to the sun is maximized.

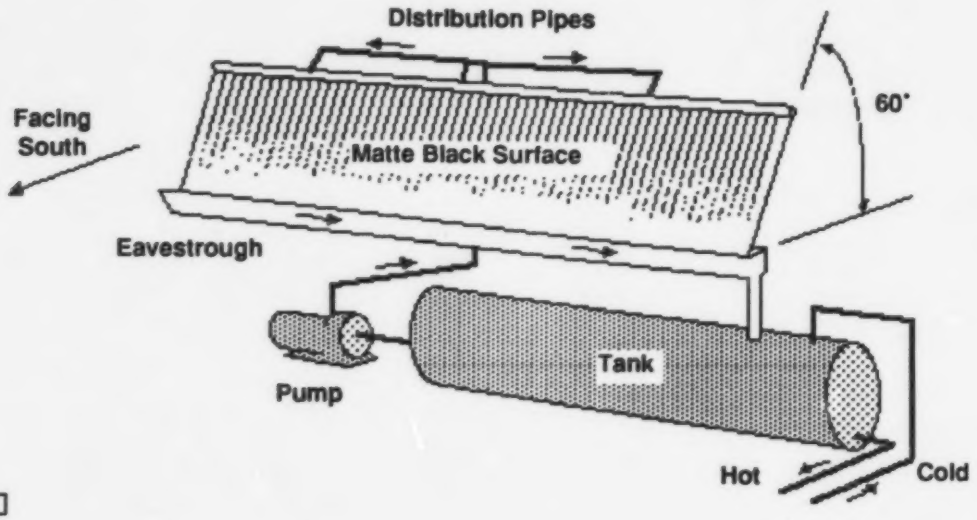


Figure 24
Trickle Heat Collector

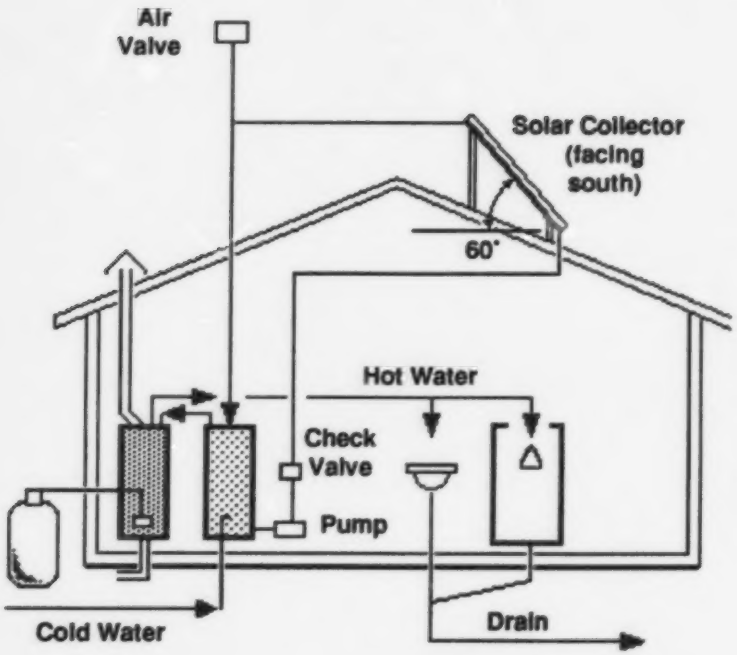


Figure 25
Solar Collection System

Economics from the Owner's Perspective

Simple Payback Analysis

How does a lodge determine if a project under consideration will benefit the operation and how long will it take for the investment to pay off? There are several things to consider:

1. Convenience to guests
2. Cost of project
3. Cost of borrowing money
4. Investment of the lodge owner's time and other resources
5. Maintenance and cost of operation
6. Spare parts
7. Training of personnel

Money

How much does it really cost? Assume a lodge operator is considering a $25,000 energy saving project which will cost $3,000 per year to operate and maintain but will save $7,200 per year over his current operation, or net savings of $4,200.00 per year before taxes ($3,150.00 after taxes).

The system under consideration has a life of 15 years. Loans are available at 12% for a 5 year loan. Using the monthly mortgage table (available at any bank, library or trust company), the monthly payement for a $25,000 loan at 12% repaid over 60 months is $552.47.

Cost of loan = (60 x $552.47) - $25,000 = $8,147.69

The lodge generates $100,000/yr in business and costs $72,000/yr to operate - net income $28,000.

The new energy savings equipment has a Class 34 Capital Cost Allowance (CCA) Deduction which allows the owner to depreciate the new equipment over 3 years.

25%	in the first year
50%	in the second year
25%	in the third year

Since revenues are less than $200,000 the lodge is classified as a small business and subject to a 25% tax rate. The owner would pay $7,000.00 in taxes on the $28,000.00 net income. Assuming his operation stays constant at $100,000/yr, the interest and capital cost of the new equipment can be used to reduce taxes:

Int. 25% of $8,147.69 =		$2,036.92
CCA	25% of 25% ($6,750) =	1,562.50
	25% of 50% ($12,500) =	3,125.50
	25% of 25% ($6,250) =	1,562.50
Total Tax Reduction		$8,287.42

Payback Period = $\frac{\text{Net Cost}}{\text{Annual Savings}}$

$\frac{25,000 + 8,147.69 - 8,287.42 + 9,534.81}{3,150}$ = 10.9 years

Savings over 15 years = 15 x 4,200 - $24,860.77*
= $38,139.23

or $28,604.42 after taxes at 25%

** Capital + Interest - Tax Deduction*

Example of Energy Conservation

John Lodge has eight uninsulated cabins which are heated with propane. Each cabin has a 20,000 Btu/hr space heater. Each cabin uses approximately twelve 100 cylinders of propane per year for heating. Each refill costs $32.00 plus $5.00 freight. John calculates it will cost $850.00 to insulate each cabin using R20 glass batts in the roof, R12 foam in the walls and R12 glass batts under the floor. This cost included caulking weatherstripping and an air vapour barrier. After renovations, John found each insulated cabin uses 7 cylinders per year.

Annual cost to heat	(uninsulated) 12 x 37 =	$444.00
	(insulated) 7 x 37 =	$259.00
Annual savings per cabin		$185.00

Payback period 850 ÷ 185 = 4.6 years

Alternate Energy

Cost Analysis for a Boiler/Steam Engine

A lodge with 15 cabins has an electrical load requiring 45 kW of diesel generated electricity. The diesels are old and the owner is considering a steam engine driven alternative. Three new diesel units would cost $36,000.00 plus freight. The diesels run at an average 30 kW load for 9 hours per day. Their fuel consumption is 0.40 lbs/hr/hp.

Diesel hp = $\frac{30 \times 1.34}{.85 \text{ (efficiency)}}$
= 47.3 hp

Fuel consumed in a 140 day season
= 0.4 lbs/hr x 47.3 hp x 140 x 9
= 23839.2 lbs or 13197.8 litres

Cost of diesel fuel delivered $.48/litre
13197.8 x .48 = $6,335.41

The lodge is 15 miles from a forest products company which is looking for some method of disposing of their wastes on a daily or weekly basis. The lodge owner determines that the company is financially sound and well managed such that it can be counted on for fuel for the next fifteen years. In addition, the company has a two year waste stockpile which the lodge owner can access at any time.

The lodge owner knows he can depend on each new diesel for 20,000 hours of service, 15.8 years at his current load.

Diesel fuel for 15 years $95,031.51. Maintenance is $1500.00/year, ($22,500.00). The owner can contract wood fuel haulage for $160.00/week for 20 weeks $3,200.00) or $48,000.00 over 15 years, discounting inflation.

With the steam engine alternative the waste steam can be used for heating hot water and heating buildings. Building heating costs are $20,000.00 per year. Hot water is now provided by propane hot water heaters in each cabin; two in the main lodge, a total of 17. Each consumes about $1,600.00 of propane per season for a total of $27,200.00 per year.

The lodge accommodates 800 tourists per year and gross revenues are $600,000.00 against operating costs of $525,000.00 allowing $75,000.00 net income, subject to 25% tax rate.

The project cost is estimated at $335,000.00.

Yearly operating and maintenance costs would be $20,000.00 per season for the boiler steam engine alternative. The owner is eligible for a 15% grant through the Energy from Waste Program provided by the Ontario Ministry of Energy.

Savings are calculated as follows over 15 years:

Costs Replaced	
Diesel Fuel	$95,031.00
Maintenance	$22,500.00
Propane	$408,000.00
Building Heat	$300,000.00
	$825,531.00

Costs Incurred	
Wood Costs	$48,000.00
Operating Cost	$300,000.00
	$348,000.00

Savings (pre-tax)	$477,531.00
Savings (after taxes)	$358,148.25
Project Cost	$284,750.00
($335,000.00 minus 15%)	

Financing can be arranged at 11% for a 5 year term for $200,000.00, monthly cost $4,324.17.

$4,324.17 x 60 =	$259,450.20
Capital	$200,000.00
Interest	$59,450.20

Tax Reduction

25% of interest	=$14,862.55
CCA Class 34 Deduction	
25% of 25% of $284,750.00	=$17,796.88
25% of 50% of $284,750.00	=$35,593.75
25% of 25% of $284,750.00	=$17,796.88
Total Tax Reduction	$86,050.05

Total savings (including taxes on net income) over 15 years:
$358,148.25 + $86,050.05 = $444,198.30 or
$29,613.22 per year

Payback is $284,750.00 ÷ $29,613.22 = 9.6 years

Example Projects

Small Hydroelectric

Small Electric Power for Frontier Lodge, 30 Miles North of Elliot Lake

John and Betty Middleton, owners of a well-established hunting and fishing lodge, recently installed a 80 kW hydroelectric system. This provides electric power for the 5,600 sq ft two story lodge and the adjacent 14 cabins, some log and some wood frame construction. Prior to this installation, the lodge used diesel generators, supplemented by wood and propane for space heating.

The lodge is located on McElrea Lake which is fed by Rottier Lake some 100 feet above through the Rottier Creek. The owners were aware of the potential and retained an engineering consultant to assist in the development. The project was completed in the following manner:

- The river flow was measured at a 25 foot long straight stretch using the parallel wire float method over a 15 month period
- Meteorological and hydrological records were researched in conjunction with topological maps of the area
- A firm flow of 10.6 cubic feet per second was finally calculated
- The proposed pipeline route between the two lakes was surveyed, confirming a head difference of 102 feet
- Pipeline losses, intake and exit losses were calculated leaving a net head of 92 feet
- A 20" diameter Sclair pipe was selected based on cost, ease of installation and low friction losses
- A list of material, equipment and contractable work was produced
- Quotations were requested from suppliers and contractors
- A project estimate was developed giving an overall cost of $202,000.00 (1982 prices) broken down as follows:

Site preparation and roads	11%
Pipeline	24%
Turbine, generator and controls	32%
Intake and powerhouse	8%
Transmission line	5%
Upgrading of existing electrics	10%
Engineering	10%

- Annual cost savings of $30,000.00 were calculated using fuel consumption figures from previous years, current (1982) diesel propane and wood fuel prices, plus the difference in maintenance cost between diesel and hydro
- Approvals were obtained from the Ministry of Natural Resources and the Ministry of the Environment
- The next step was the most difficult; arranging bridging loans. The Ministry of Industry and Trade awarded a grant of $50,000.00 payable on completion of the project. Raising $200,000.00 in unsecured loans required the assistance of the Northern Ontario Development Corporation and the MPP for Elliot Lake.
- Materials and equipment were ordered
- Construction was straight forward as follows:

- Clear access road
- Take delivery of material and equipment
- Lay in pipe foundations and supports, powerhouse foundation
- Tow the pipe into location
- Attach intake and screen to pipe, lower into lake
- Place turbine and generator in position, connect pipes and valves
- Complete power house walls, roof, install controls and transmission line
- Test turn turbine and generator fill waterline, open valves and test run turbine generator
- Check out controls and safety systems
- Commence operation

Summary of Equipment Costs

1. Galt turbine 12" diameter fixed pitch propeller type with regulation wicket gates complete with beltdriven 80 kW 3 Phase 600 volt 1,000 rpm Kato generator and Thompson and Howe electronic load controller Cost: $65,000.00

2. 12 volt motor operated butterfly inlet valve for emergency shutdown, driven from 12 volt battery comlete with 6" coupled bypass valve to maintain flow to prevent freezing of penstock in winter
   Cost: $1,500.00

3. 600/4,200 V step up transformer, transmission line and step down transformer 4,200 V to 220/110
   Cost: $9,500.00

4. 1,815 feet of 20" Sclair pipe
   Cost: $48,000.00

5. Fabricated intake and powerhouse
   Cost: $16,000.00

6. Road and pipeline bed
   Cost: $22,000.00

7. Engineering
   Cost: $20,000.00

Solar Energy

Photovoltaic/Diesel Hybrid Power System

Tarryall Resort in Keewatin were interested in determining the advantages of converting their existing diesel generator into a battery charging system, and using a photovoltaic system in conjunction with a battery storage system. Previously, Tarryall Resort produced all of its electrical energy by operating a 7.5 kW diesel generator continuously with a 3 kW diesel as a back-up unit. The owner noted that the diesel generator was only required to produce peak power for a few periods each day. For the remaining time the load averaged only 600 kW.

Consideration was given to using a storage battery system in conjunction with the diesel. Using this system the diesel would charge the batteries from which the resort power would be drawn. However the charging characteristics of batteries require a long finish rate charge period after the main portion of recharging has taken place. This again would have the diesel operating at a much reduced load, the type of operation the owner wished to avoid. To fill this gap a photovoltaic system was selected. This would supplement the battery charging and provide the lengthy finish charge to return the battery to a "fully charged" condition thereby enhancing the overall system efficiency.

The batteries provide Direct Current (DC) power which can be used for radio's, lighting and telephone. To convert DC power 115 AC (Alternating Current) an inverter is required. The inverter selected is rated at 5 kW continuous power output and is connected directly to the resort's AC distribution panel. An automatic transfer switch was provided so that the generator could pick up part of the resort's power demand when the batteries reached the low charge level.

The photovoltaic array is rated at 564 watts (peak). A 55 kW battery with a 200 amp, 24 Volt DC battery charger was utilized.

The owner, with the assistance of Sun Direct Energy Inc., the Ontario Ministry of Energy and Energy, Mines and Resources, Canada decided to proceed with the project.

Project Costs

Conversion of diesel generator	$1,821.00
Battery charger	$1,625.00
Batteries	$11,097.00
Inverter	$2,505.00
Photovoltaic array	$8,190.00
Transfer switch (charge controller)	$540.00
Associated panels and controls	$2,827.00
Engineering and installation	$4,395.00
Total	$33,000.00

Prior to installing the photovoltaic/diesel hybrid power system, the diesel generators used 13,761 litres of fuel each year. Diesel fuel costs $.34/litre. The diesels required an oil change every 200 hours of operating time, 52 oil changes per year at a cost of $1,300.00. In addition, the diesel generator required a major overhaul every three years, costing $3,000.00.

After installation fuel consumption was reduced to 2,500 litres/year, an 82% decrease. Similarly oil change costs were reduced to $250.00 per year. With the reduced operating time, the diesel generator would not require an overhaul for the next 12 years. Barring any unforeseen failures, this will save $1,850.00 per year.

Annual Savings

Reduction in fuel costs	$3,630.00
Reduction in oil changes	$1,050.00
Reduction in overhaul costs	$1,850.00
Total savings	$6,530.00

Payback period = $33,000.00 ÷ $6,530.00 = 5 years

The simple payback period for the photovoltaic/diesel hybrid power system is 5 years. A more detailed payback calculation would take into consideration the Class 34 Capital Cost Allowance and a deduction for any interest on loans for the project. This would show a further saving and shorter payback period.

Solar Collectors Displace Propane Hot Water

An 8 cabin lodge with 28 guests and a staff of 4 (32 persons total), hot water requirements of 320 gallons/day. This in now provided by 8 propane hot water heaters (each rated at 35,000 Btu/hr). The owner decides to install solar heating in two cabins to test the system:

The cost of each solar system is $2,400.00 each, including delivery. The owner does his own installation and retains the propane water heaters as back-up units.

Water is brought in through the solar system then routed to the propane heater. Both tanks are overwrap insulated. Direct sunlight is available from 8:00 am to 4:00 pm.

Morning showers use the propane system after which it is shut off. The temperature of the lake water supply ranges from 40°F in May to 68°F in September. The panels (rated at 250 Btu/sq ft/hr) produce an average 175 Btu/sq ft/hr, the loss isdue to overcast, rain etc..

The two panels have an area of 50 sq ft and deliver (50 x 175 x 8) 70,000 Btu. Tank capacity is 40 gallons or 400 lbs. of water. To raise each pound of water from 40°F to 180°F requires 140 Btu.

70,000 ÷ 140 = 500 lbs or 50 gallons
(one gallon weighs 10 lbs)

Allowing for heat losses the two panels will heat 40 gallons per day.

Evening showers and wash-up can be done with solar heated water.

Is it worth the cost?

Propane costs $.35 /l ($38.00 to fill a 100 lb tank). The cost of transport is $25.00 per cylinder. Each cabin uses 1.5 cylinders per week over a 20 week season.

Cost of propane per cabin $1,890.00/yr. The propane is also used for cooking and refrigeration which account for 18% of the propane or $283.50. Cost to heat water is $1,606.50/yr.

Cost of solar equipment - $2,400.00

Cost to run the solar equipment:

1/8 hp pump motor x 8 hr/day x 1.34 kW/hp x 20 weeks x $.80/kWhr = $21.50

Propane use is reduced by 50%.
Savings = $1,606.50/2 - $21.50 = $781.75/year

Payback period = $2,400.00 ÷ $781.75 = 3.07 years

Heat Reclaim of Diesel Generator Waste Heat

The cost of modifying a diesel generator cooling system to provide hot water will vary with the size, type of diesel and the arrangement of the lodge. The following example is provided as a guide to determine the payback.

Northern Lodge uses propane for cooking, spaceheating and hot water. The seven cabins and the lodge have an adjacent 15 kW diesel generator. The lodge used $9,000.00 worth of propane in 1986 purchased at $.42/litre. Approximate use was:

Cooking 50%	$4,500.00
Space Heating 20%	$1,800.00
Hot Water 30%	$2,700.00

The lodge has a 40 gallon propane hot water tank for the central wash up and shower. The tank is too small for peak demand for hot water. Electrical demand brings the diesel up at 4:30 a.m. as some guests enjoy fishing before breakfast.

Northern decided to install a second hot water tank on the diesel as shown in Figure 26, with a thermostat arrangement to cut out the diesel's cooling radiator until the second tank and the interconnected propane heated tank were up to temperature. Here's what it cost:

Second tank	$200.00
Piping (copper)	$200.00
Flexible hoses	$50.00
Clamps	$50.00
Fittings	$80.00
Valves	$120.00
Thermostat valve	$290.00
Tank Insulation and wrapping	$80.00
Exhaust jacket*	$400.00
New rad cap	$10.00
Pipe insulation	$160.00
Cleaning chemicals	$40.00
Owner's labour	$0.00
Total	$1,680.00

*Owners are advised to buy exhaust jacket- heat exchange from the manufacturer as these have protection against back leakage of water into the diesel which would result in damage.

Using the scheme shown in Figure 26, the diesel water tank can be bypassed if necessary.

By adjusting the thermostats, the diesel heated water extended the amount of hot water available and reduced

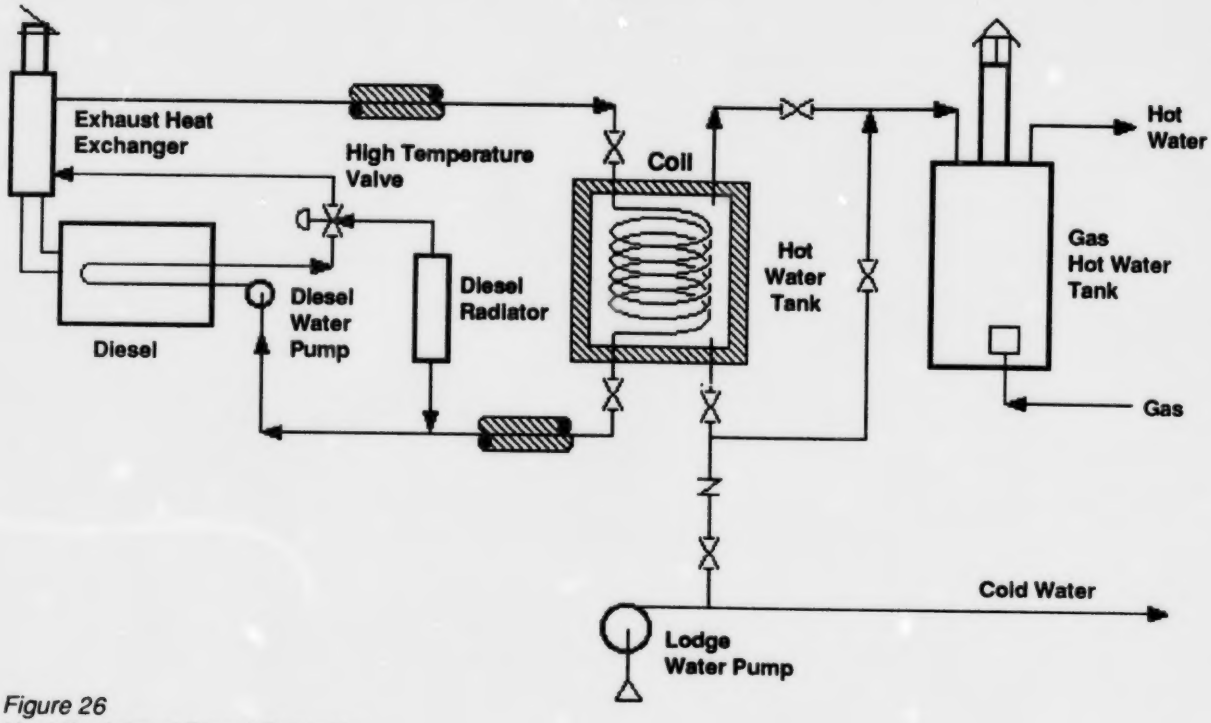


Figure 26
Heat Reclaim of Diesel Generator
Waste Heat

the propane bill by $950.00. The installation paid for itself in two seasons.

Owners are advised to check their proposed arrangements with the diesel manufacturer to ensure safe operation and that the equipment warranty is not voided by the modification.

If considering the purchase of a new diesel generator, units which incorporate this hot water capability are commercially available.

Example of Wood Heating

Henry Lodge has ten log cabins heated with propane. Ten 100 lb cylinders are required annually to heat each cabin. Including freight charges, each refill costs $40.00. Since a large supply of waste wood is available from a nearby wood cut, Henry is considering the use of a wood stove for each cabin. Including costs for chainsaw, snow mobile and woodsplitter gas and repairs, Henry estimates each cord would cost $30.00. The high efficiency convection type wood stove would cost $800.00 to purchase and install complete with a combustion air duct.This stove has a secondary burn chamber designed to burn the liquids and gases from the wood. With this stove, 2 cords per year would be required to heat each cabin.

Payback calculation for each cabin

Cost to heat with propane	10 x 40 =	$400.00
Cost to heat with wood	2 x 30 =	$60.00
Annual savings		$340.00
Project Cost		$800.00

Payback period 800 ÷ 340 = 2.35 years

Financial Assistance Programs

Ministry of Energy

Small Hydro Assistance Programs

Grant of up to $3,000.00 for engineering assessment, 50% of financial/legal evaluation up to $5,000.00 and 33-1/3% of elegible costs for small or micro hydro installations.

Small Hydro Program, Ontario Ministry of Energy
56 Wellesley Street West
Toronto, Ontario M7A 2B7

Energy From Waste Energy Program

Designed to encourage private companies and local municipalities to burn wastes to produce electricity, steam or hot water. Support up to 15% of total captial cost, owner's equity must exceed government assistance.

Ontario Ministry of Energy
8th Floor, 56 Wellesley Street West
Toronto, Ontario M7A 2B7

Ministry of Revenue

Small Business Development Corporation Program

Designed to introduce small businessmen to Ontario investors for project equity.

Small Business Development Corporation Program
Ministry of Revenue
33 King Street West
Oshawa, Ontario L1H 8H9

Ontario Development Corporation

NORDEV Program designed to encourage resource development, employment, diversification and tourism development. Assistance depends on the project, loans and, with specified criteria, forgivable loans up to $100,000.

Ontario Development Corporation
56 Wellesley Street West
Queens Park, Toronto, Ontario M7A 2E7

Ministry of Tourism and Recreation

Destinations North Program

Large scale tourism development program, assistance with developments exceeding $1 million.

Capital construction program designed for projects over $40,000.00, asistance with loans to 50% of $100,000.00, for expansions 50% or $200,000.00 and for new developments 50% to $500,000.00. Loans are ODC rate base less 2%.

Tourism Redevelopment Incentive Program (Trip)*

90% loan guarantee with interest rate subsidy

Term loans*

*Administered by Northern Ontario Development Corporation

273 Third Avenue
Timmins, Ontario P4N 1E2

199 Larch Street
Sudbury, Ontario P3E 5P9

435 James Street South
Thunder Bay, Ontario P7C 5G6

Suppliers and Manufacturers

Solar Panels

Asecor Ltd.,Box 929, Manotick, Ontario K0A 2N0 (613) 692-4495

Norsun, Nortec Solar Industries Inc., P.O. Box 760 Manotick, Ontario K0A 2N0 (613) 692-2513

Prometheus Energy, 7773 Yonge Street, Thornhill, Ontario l3T 2C4 (416)881-3369

Petrosun, Sun Strip International, 24 Queen Street East, Suite 609, Brampton, Ontario L6V 1A3 (416) 954-0212

Solcan Canada, RR3 London, Ontario N6A 4B7 (519) 473-0501

SunRay Solar Systems, 2429 Seminole Street, Windsor, Ontario N8T 1X2 (519) 253 1182

Solarmart, 2084 Vickery Drive, Oakville, Ontario L6L 2J3 (416) 827-2579

Sunglow Solar Limited, 35 Citron Court, Concord, Ontario L4K 2S7 (416)253 1182

Watershed Energy Systems Limited, 97 Six Points Road, Toronto, Ontario M87 2X3 (416) 233-3241

Steam Engines

Skinner Engine Company, Power Division, P.O. Box 1149, Erie Pennsylvania, 16512 (814) 454-7103

Steam Boilers

Argussree Incorporated, 20 Hunting Wood Crescent, Bramalea, Ontario L6S 1S6 (416) 458-1667

Boiler Smith Limited, 156 Main Street, Seaforth, Ontario N0K 1W0 (519) 526-0600

Babcock Wilcox Industries Limited, Coronation Boulevard, Cambridge, Ontario N1R 5V3 (519) 621-2130

Combustion Engineering Superheater Limited, Suite 501-99 Bank Street, Ottawa, Ontario K1P 6C5 (613) 560-4545

Foster Wheeler Limited, P.O. Box 3007 St. Catharines, Ontario L2R 7B7 (416) 688-4434

Volcano Incorporated, 1990 Ellesmere Road, Unit 15, Scarborough, Ontario M1H 2W2 (416) 438-9680

Photovoltaics (Solar Cells)

Bayly Engineering Limited, 167 Hunt Street, Ajax, Ontario L1S 1P6 (416) 683-8200

Mechron Energy Limited, 2437 Kaladar Avenue, Ottawa, Ontario K1V 8B6 (613) 733-3855

TPK Solar Systems Incorporated, 36 Bentley Avenue, Napean, Ontario K2E 6T8 (613) 225-4403

Lenbrook Industries Limited, 1145 Bellamy Road, Scarborough, Ontario M1H 1H5 (416) 438-4610

Solarpak Energy Systems Limited, 1535 Meyerside Drive, Unit 6, Mississauga, Ontario L5T 1M9 (416) 674-1616

Intersolar Group Canada 415 Brian Court, Pickering, Ontario L1W 3H5 (416) 420-6897

Photron Canada P.O. Box 136 Colinton, Alberta T0G 0R0 (403) 675-2586

Westronic Inc., 4525 Manila Road S.E., Calgary, Alberta T2G 4B6 (403) 243-3335

Sun Direct Energy Inc., P.O. Box 136, Colinton, Alberta T0G 0R0 (403) 675-2586

Turbines, Hydraulic 10 kW to 150 kW

Barber Hydraulic Turbine Limited, P.O. Box 340, Port Colbourne, Ontario L3K 5W1 (416) 834-9303

Dependable Turbine Incorporated, 7-3005 Murray Street, Port Moody, British Columbia

Galt Energy Systems Limited, P.O. Box 1354 Cambridge, Ontario N1R 3B0 (519) 623-1390

Leroy Somer, 5456 Tomken Road, Unit 1011, Mississauga, Ontario L4W 2Z5 (416) 624-2733

Small Hydro Electrics, P.O. Box 54, Silverton, British Columbia V0G 2B0

Penstocks

Canbar Incorporated, P.O. Box 280, 1 Canbar Street, Waterloo, Ontario N2J 4A7 (519) 866-2880

Hydrolec North American Incorporated, 925 Leroy-Somer Boulevard, Granby, Quebec J2G 8E2 (514) 378-0150

Trashracks

Atlas Polar Company Limited, Hercules Hydro Division, P.O. Box 160 Station O, Toronto, Ontario M4A 2N3
(416) 751-7740

Hydrolec North American Incorporated

Gates

Barber Hydraulic Turbine Incorporated

Hydrolec North American Incorporated

Load Management Systems (Peak Load Control System)

ADT Energy Systems Ltd., 5734 Yonge Street, Willowdale, Ontario M2M 3T3 (416) 226-9221

Enera Systems Inc., 1215 Meyerside Drive, Unit 6, Mississauga, Ontario L5T 1H3 (416) 673-2656

Johnson Controls Ltd., Control Products Division, 929 Warden Avenue, Scarborough, Ontario M1L 4C6 (416) 755-1137

MCC Powers, 6700 Finch Avenue W., Suite 600, Rexdale, Ontario M9W 5P2 (416) 675-1810

Cycle Charge Systems

Mechron Energy Limited, 2437 Kaladar Avenue, Ottawa, Ontario K1V 8B9 (613) 733-3855

Storage Batteries

Allied C-D Batteries, Unit 15, 150 Connie Crescent, Concord, Ontario L4K 1B6 (416) 667-0179

B & M Tire and Battery Ltd., 2599 Tecumseh Rd. W., Windsor, Ontario N9B 1W4 (519) 252-7291

Canada Commercial Ind. Battery 5597 Timberlea Blvd., Mississauga, Ontario L4W 2S4 (416) 624-9060

Chloride Canada Limited, 7480 Bath Rd., Mississauga, Ontario L4T 1L2 (416) 677-8771

Duracell Inc., 2333 North Sheridan Way, Mississauga, Ontario I5K 1A7 (416) 823-4410

Exide Canada Corp., 2301 Dixie Rd., Mississauga, Ontario L4Y 1Z9 (416) 277-3131

Hay Battery Limited, 1 Dunbar Ave., Hamilton, Ontario L8H 3H3 (416) 544-5596

Prestolite Battery Battronics, 8301 Keele St., Maple, Ontario L0J 1E0 (416) 669-9326-7

Saft Batteries Limited 200 Middlefield Rd., Scarborough, Ontario M1S 4M6 (416) 298-7322

Tenatronics Limited, P.O. Box 185 Newmarket, Ontario L3Y 4X1 (416) 895-4583

Varta Batteries Ltd., 2 Lansing Square, Suite 601 Willowdale, Ontario M2j 4P8 (416) 494-1457

Wood Stoves

Robert Bell Industries Ltd.,Seaforth, Ontario N0K 1W0, P.O. Box 70 (705) 527-0600

Corbron Foundries Ltd., Cornwall, Ontario P.O. Box 1119, K6H 5V2 (613) 938-9221

Elmira Stove Works, 22 Church St. W., Elmira, Ontario
N3B 1M3 (519) 669-1281

Heritage Stove Co. Ltd., 23 Balsam St., Collingwood, Ontario L9Y 4H7 (705) 445-5650

Hevac Mfg. Ltd., 4390 Paletta Court, Burlington, Ontario L7L 4X5

Hunter Enterprises Orillia, Limited, Orillia, Ontario, P.O. Box 400 I3V 6K1 (705) 325-6111

Lakewood Manufactiring, Bobcaygeon, Ontario, P.O. Box 489 k0M 1A0 (705) 738-2393

More-Heat Stoves, 4 Nihan Dr., St. Catharines, Ontario L2N 1L1(416) 934-5552

Newmac Mfg., P.O. Box 545 Woodstock, Ontario N4S 7Y5 (519) 539-6147

O'Dette Energies of Canada Ltd., 595 O'Connor Dr., Kingston, Ontario K7P 1J9 (519) 549-0121

Old Timer Distributing, 57 Edwin St. S., Kitchener, Ontario N2H 4N7 (519) 744-8202

Wolfedale Engineering Ltd., 3644 Wolfdale Rd., Mississauga, Ontario L5C 3E6 (416) 275-4948

Wind Turbine Systems

Adecon Energy Systems Inc., 32 Rivalda Rd.,
Weston, Ontario M9M 2M3 (416) 745-2416

First Canadian Energy Corp., 201-1226 Homer St.,
Vancouver, British Columbia V6B 2Y5 (604) 688-7828

Helio Beauce, 680 30th St., Ville St. George, Bauce,
Québec G5Y 4H4 (418) 228-0049

Hewder Group Canada Ltd., 1510 Birchmount Rd.,
Scarborough, Ontario M1P 2G6 (416) 752-7310

Indal Technologies Ltd., 3570 Hawkestone Rd.,
Mississauga, Ontario L5C 2V8 (416) 275-5300

Marapat Wind Power Ltd., Box 197 Stirling, Alberta
T0K 2E0 (403) 756-3904

Massey Enterprises, Box 1299, Fort McLeod, Alberta
T0L 0Z0 (403) 553-3552

MIL VICKERS Inc., 5000 Notre Dame St. E., Mintreal,
Québec H1V 2B4 (514) 256-2651

Thermax Energy Corp., 39 Main St., Van Kleek Hill,
Ontario K0B 1R0 (613) 678-3332

Wellington Wind Power\ P. O. Box 15, Wellington,
Ontario K0K 3L0 (613) 399-3171

References

There are many excellent references on Energy Conservation and Alternate Energies. The books and government publications listed below are available from the library of the Ontario Ministry of Energy. Periodicals may be obtained through libraries.

Books

Low Cost Development of Small Water Power Sites
VITA Bookshop, 3706 Rhode Island Avenue
Mount Rainier, Maryland, USA 20822

Small Hydro '86 Proceedings
Ontario Ministry of Energy 1986 ISBN 0-7729-1542-3

Wood-Fired Boiler Systems for Space Heating
US Department of Agriculture, Forest Service
Biomass Energy Program
Contact the Superintendent of Documents
US Government Printing Office, Washington DC 20402

Ontario's Water Power Sites
Ontario Ministry of Natural Resources
Contact MNR Public Information Centre
Room 1640, Whitney Block
99 Wellesley Street West
Toronto, Ontario M7A 1W3

Government Publications

Home Energy Fact Sheets
Ontario Ministry of Housing, Housing Conservation Unit
Queen's Park, Toronto, Ontario M7A 1N3

- *Caulking and Weather Stripping*
- *Insulating Basements*
- *The Total Tune-up for Gas, Oil and Electric Forced Air Systems*
- *Air Vapour Barriers*
- *Cathedral Ceilings and Flat Floors*
- *Improving Fireplace Efficiency*

Enerfacts
Energy, Mines and Resources Canada
Toll Free Heatline: 1-800-276-9563

- *Improving the Energy Efficiency of Windows*
- *Weather Stripping*
- *How to Detect and Seal Air Leaks*
- *Caulking*
- *Insulation Summary*

Keeping the Heat In
Energy, Mines and Resources Canada
Heatline: 1-800-267-9563

Understanding Solar Technology
Energy, Mines and Resources Canada
Renewable Energy Division, Suite 606
55 St. Clair Avenue E.
Toronto, Ontario M4T 1M2
Toll Free: 1-800-268-1197

Small Hydro, A Natural for Ontario
Ontario Ministry of Energy, Small Hydro Program
56 Wellesley Street West
Toronto, Ontario M7A 2B7

The Billpayer's Guide to Home Heating
Energy, Mines and Resources Canada

Heating With Wood
Energy, Mines and Resources Canada

Appliance and Prime Mover Data

Electric Appliances	Motor Sizes* @ 115 Volts	Full Load Amperage
Refrigerator	1/6 to 1/4 hp	2.5 to 4.1
Freezer	1/5 to 1/4 hp	2.8 to 4.1
Automatic Washing Machine	1/3 hp	6.0
Dish Washer	1/3 hp	6.0
Water Pump	1/3 to 1/2 hp	5.0 to 6.7
Coffee Maker		7.8
Toaster, Waffle Iron or Kettle		10
Colour Television		1.7
Vacuum Cleaner		5.5

Starting amperage for motors can be 6 times the full load amperage.

Propane Appliances	Energy Use Rate
Refrigerator	1,500 - 2,000 Btu/hr
Freeezer	1,200 - 1,500 Btu/hr
Stove Burner (small)	9,100 Btu/hr
Stove Burner (large)	12,000 Btu/hr
Stove Oven	18,000 Btu/hr
Hot Water Heater (33 gallons)	31,500 Btu/hr
Hot Water Heater (40 gallons)	40,000 Btu/hr
Clothes Dryer	20,000 Btu/hr (+ 6.8 amp motor)

Prime Movers	
Gasoling Engine	0.32 to 0.35 l/hp/hr
Diesel Engine	0.22 to 0.24 l/hp/hr

Glossary and Conversion Factors

Length

1 metre = 3.28 ft = 39.36 inches
1 centimetre = 0.394 inches

Volume

1 cubic metre	= 264 US gallons
	= 220 Imperial gallons
	= 1,000 litres
	= 35.3 cubic feet
Imperial gallon	= 4.545 litres

Pressure

1 Kilopascal = 0.145 pounds per square inch (psi)

Weights

1 Imperial gallon of water	= 10 lbs	= 4.54 kilograms
1 Imperial gallon of gasoline	= 7.2 lbs	= 3.27 kilograms
1 Imperial gallon of diesel fuel	= 8.2 lbs	= 3.72 kilograms
1 litre of propane	= 0.89 lbs	= 0.40 kilograms
1 kilogram	= 2.2 lbs	
1 lb	= .454 kg	

Heat

1 kilowatt hour	= 3,413 British Thermal Units (Btu)
1 Kilojoule	= 0.947 Btu

Power

1 Kilowatt = 1.34 horsepower (hp)

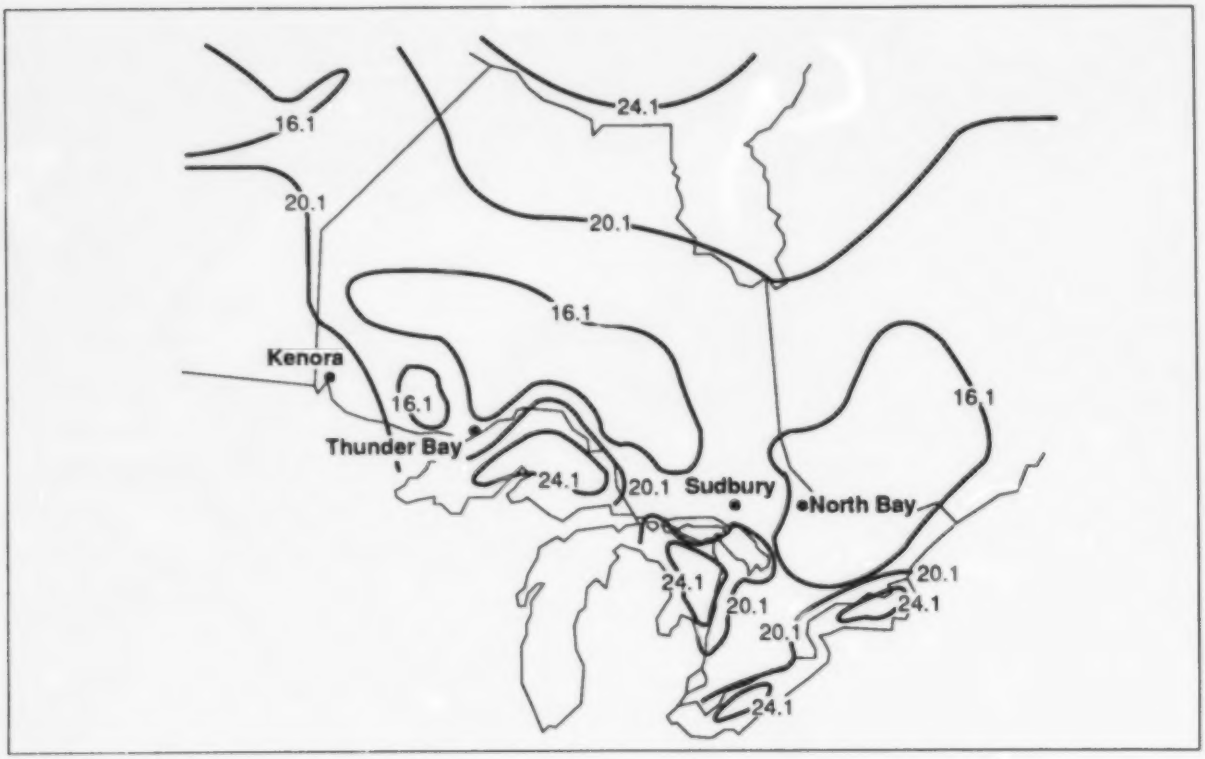
Flow

1 cubic metre per second = 35.3 cubic feet/second

Thermal Content

1 litre of diesel fuel = 36,600 Btu = 38.7 million Joules
1 litre of propane = 24,218 Btu = 25.6 million Joules
1 kilowatt hour of electricity = 3.6 million Joules
1 cord air-dry spruce = 19,200 million Joules

Average Wind Velocities in Ontario



Note: Isovents of annual mean wing speed in kilometres per hour at 30 metres altitude

Figure 27
Average Wind Velocities in Ontario